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THE KINGDOMS OF ORGANISMS

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THIS paper proposes the recognition of certain groups of living creatures as kingdoms in addition to the two which are conventionally recognized.

Revision of the primary classification of organisms is a taxonomic operation, governed by taxonomic principles; it differs from revision of a family or genus only in wider scope. Because of the human need of an arrangement of organisms which will express as fully as possible existing knowledge and opinion concerning them, all groups are always subject to revision. Revision is required whenever the currently accepted groups can be replaced by more nearly natural groups. In practice, a group is held to be natural if each of its members is bound to the others by the whole range of its characters, of which some may be common to the whole group, while those in which there is variation exhibit intergradation. Assuming evolution to be a fact, this continuity of character is interpreted as representing, and the quality of naturalness is regarded as identical with, the possession of a common ancestor. Very many of the accepted taxonomic groups are, so far as knowledge can be positive, positively natural. Others are less positively natural; there is an unbroken transition to acknowledged artificialities, groups maintained for the disposition of races too poorly known as yet to permit of their disposition according to relationship.

The ancestor of a particular group, unless it was the original form of life, must also have had ancestors; and from these, if we go back far enough, we will always find collateral descendants. Accordingly, the limits of each natural group are indefinite at one or more points where there are transitions to related groups. We can give broader limits to any group by taking into account a more distant common ancestor, or narrower limits by considering a more recent one. The limits assigned to a particular group, one which is named, assigned to a definite taxonomic category, and defined by description, are always artificial, arbitrary, decided by convenience. Convenience at this point means something subordinate to the overriding convenience or necessity of recog-

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nizing groups which are natural. A conservative element of convenience is familiarity: the taxonomist is loath to propose abandonment of a familiar arrangement unless he can propose one in better conformity to relationship. Another element of convenience lies in the varying inclusiveness proper to groups of different categories: phyla and classes should not be too numerous; families and genera should not be too extensive. A third element of convenience lies in feasibility of definition by description; this is often attained by making limits coincide with "missing links," that is, with breaches of knowledge.

The formulation of a system of classification, then, involves a double set of hypotheses: hypotheses as to the ancestry, origin, and evolution of groups, and hypotheses as to what boundaries will be found expedient. A principle useful in the formulation of hypotheses as to the history of groups may here be discussed. If we find that a group of organisms consists of some which possess a certain positive character and of others which do not, we may most often interpret those having the positive character as a subordinate natural group, that is, as being the descendants of a single individual descendant of the ancestor of the greater group. To this principle, however, exceptions are exceedingly common; the same positive character can often be shown to have appeared more than once in evolution, or to have disappeared more than once. So often are we required, by convincing evidence of relationship, to admit to a group members which do not conform to its formal description that this situation may be regarded as the rule rather than the exception.

The application of these principles to the primary classification of organisms will involve breaches of convenience, particularly in the point of familiarity. It is an ancient and familiar hypothesis, too widely accepted as a law of nature, that every living creature is and must be either a plant or an animal. Judged by knowledge and theory which were available to Linnaeus, this hypothesis is sound; judged by modern knowledge and theory, it seems untenable. It was first challenged by Haeckel, whose *Generelle Morphologie* (43; see Fig. 2), in which he proposed the recognition of a third kingdom, Protista, appeared within a decade after the *Origin of Species*. The knowledge by which a tenable rearrangement of the kingdoms could be formulated was not available when Haeckel first attempted it, and although he subsequently, and more than once, rearranged his kingdom Protista, he never won for it a general acceptance. Various authors more recent than Haeckel have shown a disposition to recognize more kingdoms than two, but none of them, apparently, has formulated a system including all organisms. Pending such an accomplishment, the old system of two kingdoms has persisted for want of a workable substitute.

The scientists who find themselves under pressure to devise a more satisfactory system of kingdoms are those charged with elementary instruction in biology or in one of its main branches, as botany or zoology. The elements of the science include the principles of classification, and the teacher is responsible for presenting kingdoms which are limited in accordance with fact and law rather than with tradition. The one who taught me elementary botany made clear to his freshman students the principles of classification; he has summarized them, essentially as above, in various works on the classification of ferns (21, 23). He made it clear that the limits ordinarily assigned to the plant kingdom fail to include groups

which link together the bacteria, the various groups of algae, and the Fungi. Such limits make the kingdom unnatural and are inconsistent with the principles acknowledged. When it became my turn to undertake elementary instruction, my efforts to recognize a series of natural kingdoms led me to distinguish four of them, called Monera, Protista, Plantae, and Animalia. Further reflection and study, extending through about twelve years, have left me confident that this is the best system which can be recognized at the present time. I proceed, therefore, to discuss the four groups as I conceive them, endeavoring to show that each one is acceptable as a unit in a double sense, in evolutionary origin and for purposes of human thought.

THE KINGDOM MONERA

In his *Generelle Morphologie*, Haeckel postulated the existence of a group of organisms without nuclei; he named the group Monera (originally Moneres, but the neuter form used in later works is preferable) and included it in Protista. He is said to have postulated, rather than to have recognized or assembled, such a group, because most of the organisms which he assigned to it, *Protamoeba*, *Protomonas*, and *Vampyrella*, are either nonexistent or false to the definition. Among Haeckel's original examples of Monera, *Vibrio* is the only one representing organisms which actually exist and are interpretable as lacking nuclei.

A few years later, Cohn (19) "with that inspired insight which only unflinching diligence can impart to original genius" (these are the words which Fiske (39) applied to a different scientist and his discoveries) recognized the connection between bacteria and blue-green algae, and combined these organisms in a group which he named Schizophyta ("fission plants"). Earlier scholars (I draw this history from Bergey's *Manual* (5) and from the work of Buchanan (9)) had for the most part regarded bacteria as "animacules," and had given them a place in that group of animals which included the simplest ones and was least definitely defined, namely the Vermes. It may have been the evident relationship of bacteria to blue-green algae that convinced Cohn that they are plants; the group Schizophyta was definitely assigned to the plant kingdom.

Haeckel in his later writings (see his *Wonders of Life* (45)) recognized Cohn's Schizophyta as being the true Monera, and included them, under the latter name, in Protista.

Two authors to my knowledge (22, 106), and doubtless others whom I have overlooked, have published the opinion that the Schizophyta or Monera should be treated as a distinct kingdom. This opinion appears to be correct: I shall present evidence supporting it, but must first discuss the name by which the group is to be called.

Modern usage fixes the application of names by types rather than by descriptions. Under the type system, Monera is the valid name of the group under discussion only if *Vibrio* is recognized as the type, and only if we can attach to the name *Vibrio* some meaning which might have been in Haeckel's mind. The organisms included in *Vibrio* by Mueller, the author of the group, have not been identified. To Haeckel, *Vibrio* seems to have meant bacteria in general. To neither of them could this name have meant the subsequently discovered organism of Asiatic cholera, by which the authors of Bergey's *Manual*, in deviation from their usual nomenclatorial good form, have attempted to typify it. One can perhaps justify Monera as the name of the group

now under discussion by the assumption that to Haeckel *Vibrio* meant *V. subtilis* Ehrenberg (*Bacillus subtilis* (Ehrenberg) Cohn, the type of *Bacillus*). If *Vibrio* is not tenable as type of Monera, or if this name is meaningless, Monera becomes a synonym of Rhizopoda, or, perhaps, loses all meaning. No such ambiguity attaches to the name Schizophyta; it means, and has always meant, bacteria and blue-green algae taken together.

It will be well to take into account certain matters which, under the involved niceties of nomenclature, are not entitled to consideration. The names have connotations: Monera should be organisms without nuclei; Schizophyta should be members of the plant kingdom. As Monera is the older name; as the group is to be treated as a distinct kingdom and distinguished by lack of nuclei; as Schizophyta, applied to a group excluded from the plant kingdom, would be a misnomer and a perpetual annoyance; the name Monera will be used.

The Monera are here treated as a kingdom on the basis of two assumptions: that they are the comparatively little modified descendants of whatever single form of life first appeared on earth, and that they are sharply distinguished from other organisms by the absence of nuclei.

The hypothesis that life came into existence just once is perhaps not absolutely necessary to the treatment of this group as a kingdom. The general rule, that a tenable group is bound together by ancestry, is really a matter of convenience; such a group is bound together by the whole range of its characters rather than by a finite number of specific features. If life originated more than once, it might be expedient to make an exception to the rule by gathering into one group all of the original forms and their comparatively little modified descendants. It is possible that this is done in establishing the kingdom Monera; one prefers to suppose that this group, like any other satisfactory taxonomic group, is natural.

This is a supposition regarding events of an antiquity more easily stated than imagined. Definite fossils from time anterior to the Cambrian, which began, probably, about half a billion years ago (cf. Pirsson and Schuchert (97) and Schuchert and Dunbar (103)) are exceedingly scant. The range of pre-Cambrian time has been divided, tentatively, into two eras; Proterozoic, which commenced, perhaps, about a billion years ago, and Archeozoic, including all preceding time of which the earth harbors objective remains. Great deposits of elemental carbon in the Archeozoic seem to constitute definite proof that life was in existence at least a billion and a half years ago, but there is nothing to show what or how many forms of life were in existence. Life as it exists at present exhibits a deep-seated uniformity, bespeaking a unitary origin: all life resides in mixtures of essentially the same materials; all life obtains the energy for its immediate operations by processes of oxidation; all life (with certain puzzling exceptions among Monera; cf. Crow (27, 28) on *Spirulina*, *Arthrospira*, and other blue-green algae, and Ellis (37) on *Leptothrix ochracea*), exhibits cellular organization. Perhaps, once in existence, life spread over the world and so changed it as to prevent a repeated origin. So ancient is life, so extensive has extinction been, that we would not be convinced of its repeated origin by any amount of negative evidence, such as the absence of all trace of lines of descent connecting the various groups of Monera. On the other hand, the existence of organisms which can be interpreted as the surviving traces of lines of descent would be strong evidence of

unitary origin. I shall endeavor, by a survey of the groups of Monera, to show that such organisms exist.

The hypothesis that bacteria and blue-green algae are without nuclei (and if this hypothesis is false, the name Monera is inappropriate) involves two ideas; one is morphological, concerning the structure of organisms; the other is a matter of words, and concerns the proper use of the term nucleus. Bütschli (10; see also the textbook by Lutman (84) and the long paper by Dobell (34)) is said to be responsible for two distinct conceptions of nuclei in Schizophyta: that the whole cell of ordinary bacteria is a nucleus, and that in sulfur bacteria and blue-green algae there is a central body which is a sort of incipient nucleus, representing, but not showing all of the features of, the nuclei of higher organisms. Dobell reviewed in detail the work of forty-nine previous authors; on the basis of his own work, he concluded that bacteria definitely possess nuclei. In the following survey of the groups of Monera, I shall refer to what is known of the structure of the cells. I must leave it to the judgment of each reader whether any of the structures encountered is to be considered a nucleus.

MONERA: I. AUTOTROPHIC BACTERIA

Most autotrophic (self-nourishing) organisms, including among Monera the blue-green algae, live by photosynthesis. For this process, it is said that a green pigment, chlorophyll, is necessary: more accurately, two green pigments (forms of chlorophyll) are required, and with these there are always associated other pigments, yellow, brown, red, or blue. All these pigments are highly complicated organic compounds. Photosynthesis uses the energy of light, and accomplishes a single immediate result, the production of organic compounds. The energy for all processes except photosynthesis is obtained by processes (collectively called energesis) in which organic compounds are oxidized and destroyed. We cannot suppose that life as it first came into existence possessed substances as complicated as the photosynthetic pigments, nor that it was capable of as complicated a system of metabolism as this.

Still less can organisms which are dependent on others be regarded as primitive. Most of them can be shown to be descendants of organisms which live by photosynthesis; their metabolic system is essentially that of the photosynthetic organisms, but it has been simplified by degradation, by the loss of capacity for the energy-binding process.

Organisms more primitive than those which are photosynthetic or dependent were first discovered by studies of nitrification, that is, of the natural accumulation of nitrates in the surface of the earth. The scientists of the latter part of the nineteenth century were disposed to blame everything on bacteria; several of them attempted to discover nitrifying bacteria. Success in this attempt came to Winogradsky (126).

Only four species of nitrifying bacteria, all discovered by Winogradsky, are known. Some or all of them occur in all soils fit for agriculture; they are of very great economic importance, but it has not seemed worth while to try to control them, and they have been studied but little. Their cells are minute and presumably of the simplest structure. Their system of metabolism is called chemosynthesis: it consists in the oxidation of inorganic compounds, in this case ammonia and nitrites, and the use of the energy released to make organic compounds from carbon dioxide. Thus, in one operation it effects the results both of the photosynthesis and of the energesis of other

organisms. One feels in Winogradsky's original account the bewilderment with which he discovered that the less food he gave his organisms, the better they grew.

Pending a better understanding of the filterable viruses (none of which is known to possess any capacity for making organic compounds from inorganic) the organisms which live by chemosynthesis may be regarded as standing closer to the origin of life than any others yet known. They are, indeed, not very close to the origin of life: they are not intermediate between lifeless matter and living, but are as definitely alive as men. In addition to the nitrifying bacteria, there are other organisms in considerable number which are known or supposed to live by chemosynthesis. Following Bergey's *Manual*, one may treat them as forming three groups (see also Waksman (120)).

Close to the nitrifying bacteria may be placed a sulfur-oxidizing organism of similar character, the *Thiobacillus thiooxidans*, discovered by Waksman and Joffe (121). Here also are placed several genera of obscure organisms which oxidize such substances as hydrogen, carbon monoxide, methane, alcohol, and acetic acid. Several of these are known to be only facultatively autotrophic, and capable of living as saprophytes. These facultatively autotrophic bacteria seem to represent an evolutionary line connecting the purely autotrophic bacteria with the ordinary bacteria of disease and decay.

The order Chlamydobacteria (iron bacteria) includes only about a dozen species (cf. Ellis (37)). Some of these have long been known; the most familiar is *Leptothrix ochracea*, which forms the yellow masses by which we recognize the presence of iron in springs of water. Since the discovery of chemosynthesis, it has been supposed that the iron bacteria live by oxidizing ferrous iron to ferric, but this has apparently not been positively proved.

The order Thiobacteria is something of a miscellany; the characters are the accumulation within the cells of granules of sulfur or of salts of calcium or both, or the possession of a red pigment, or both such granules and such pigment. *Beggiatoa*, a colorless inhabitant of sulfur springs, forming filaments which exhibit a writhing movement, has long been known. Winogradsky showed that it lives by oxidation of hydrogen sulfide and elemental sulfur. Gardner (40) described the protoplasm of *Beggiatoa* as forming a network in which a central body is distinguished by greater coarseness of the strands, and apparently also by staining reactions (the preparations which he figured (Fig. 1, q) do not show the latter character). The pigmented Thiobacteria, the "purple bacteria," are, at least in part, saprophytic. They have the property of swimming toward light; it is suspected that they can to some extent use the energy of light, and that they represent a stage in the evolution of photosynthesis.

This is not the proper occasion for putting forward a new taxonomic system of Monera—that would only divert attention from my proper thesis. I have in mind, however, and have been following, a tentative outline which may as well be stated explicitly. The Monera seem not numerous enough for classification in groups of seven ranks as prescribed by the botanical and zoological codes. The category of phyla may be omitted, and the main groups of Monera treated as classes. The groups already described as including organisms which live by chemosynthesis may form a single class of three orders. The remaining Monera may form three classes, embracing respectively the ordinary bacteria or Schizomycetes (orders Eubacteria, Actinomycetes, and Myxobacteria), the spirochaets (a single order), and the blue-green algae (two or three orders).

MONERA: II. ORDINARY BACTERIA

One and only one apparent evolutionary line has been pointed out as leading from autotrophic bacteria into the group here called ordinary bacteria. The latter is a numerous group of parasites and saprophytes, many of which are familiar and of great importance. As the character of the group—physiological dependence—is negative and evidently derived, one can have no confidence that the group is natural; further study may show how to break it up.

The structure of ordinary bacteria is simple. A complete list of the morphological characters in which there are variations usable in classification would include few beyond the following: size and shape of cells; absence or presence and pattern of flagella; production or non-production of spores, gelatinous envelopes, and involution forms; a few staining reactions; characters of colonies. The Myxobacteria, an insignificant group of curiosities, produce comparatively complicated structures which may perhaps be interpreted as highly elaborated colonies.

In physiological characters, as distinguished from morphological, the ordinary bacteria exhibit a remarkable range of variations; the classification is largely based on these.

A note on the position of the nitrogen-fixing bacteria may be included here. They form three distinct groups. One, the species *Clostridium butyricum*, is in Bergey's *Manual* duly placed among ordinary bacteria. The other two, the genera *Rhizobium* and *Azotobacter*, are placed near the nitrifying bacteria. Nitrifying bacteria and nitrogen-fixing bacteria agree in being Monera and in being concerned with the nitrogen cycle. In all other respects they differ; nitrogen fixation is an endothermic process found only in parasites and saprophytes. Places for *Rhizobium* and *Azotobacter*—two different places—should be found among ordinary bacteria.

Among the numerous papers on the internal structure of cells of ordinary bacteria I cite but few. Schaudinn (101) described the exceptionally large *Bacillus Bütschlii* found in the gut of the cockroach (Fig. 1, d–g). He finds the protoplasm finely alveolar and divisible into a central body and an outer part.

When spores are to be formed, a spiral row of granules appears at the outer edge of the central body. This row breaks at the middle, each part migrates to the end of the cell nearer to it, and is involved in the formation of a spore. Each cell, accordingly, forms two spores. In *Bacillus Sporonema*, a smaller organism found as a free-living saprophyte, Schaudinn (102) was unable to find the structures just described. Swellengrebel (111) worked on *Bacillus maximus buccalis* from his own mouth (Fig. 1, a–c). He describes a peripheral spiral filament, which, in each cell division, divides lengthwise, after which the parts separate by sliding past one another as a smaller spring may be pulled out from within a larger one. Swellengrebel's figures support this surprising account, but there are no other reports to confirm it. Dobell (33) described several bacteria from the guts of frogs and toads; among these, *Bacillus flexilis* shows stages quite like those of *B. Bütschlii*, and like it produced two spores from each cell. In *Bacillus Saccobranchi*, which he discovered in the blood of a dead fish (34), he similarly found stainable material appearing either as separate granules or as a crooked, more or less spiral rod (Fig. 1, h–n). The granules or rod, as the case may be, stain as chromatin does.

It may be noted that with the exception of those of Swellengrebel, the results just summarized are drawn entirely from spore-forming rods, the group which forms the genus *Bacillus* as properly construed. Comparatively recent work on this group tends to confirm these results. According to Churchman (57), the outer part of the protoplast is different from the inner; the gram-positive character of the group depends on the outer part. The figures of *Bacillus subtilis* by Knasyi (69) and of *B. Megatherium* by Bayne-Jones and Petrilli (3) seem to show the spiral bodies of the older authors as thickenings of the ectoplasm (this is Knasyi's term; it is preferable to Churchman's "cortex"). These bodies were not found, however, to have

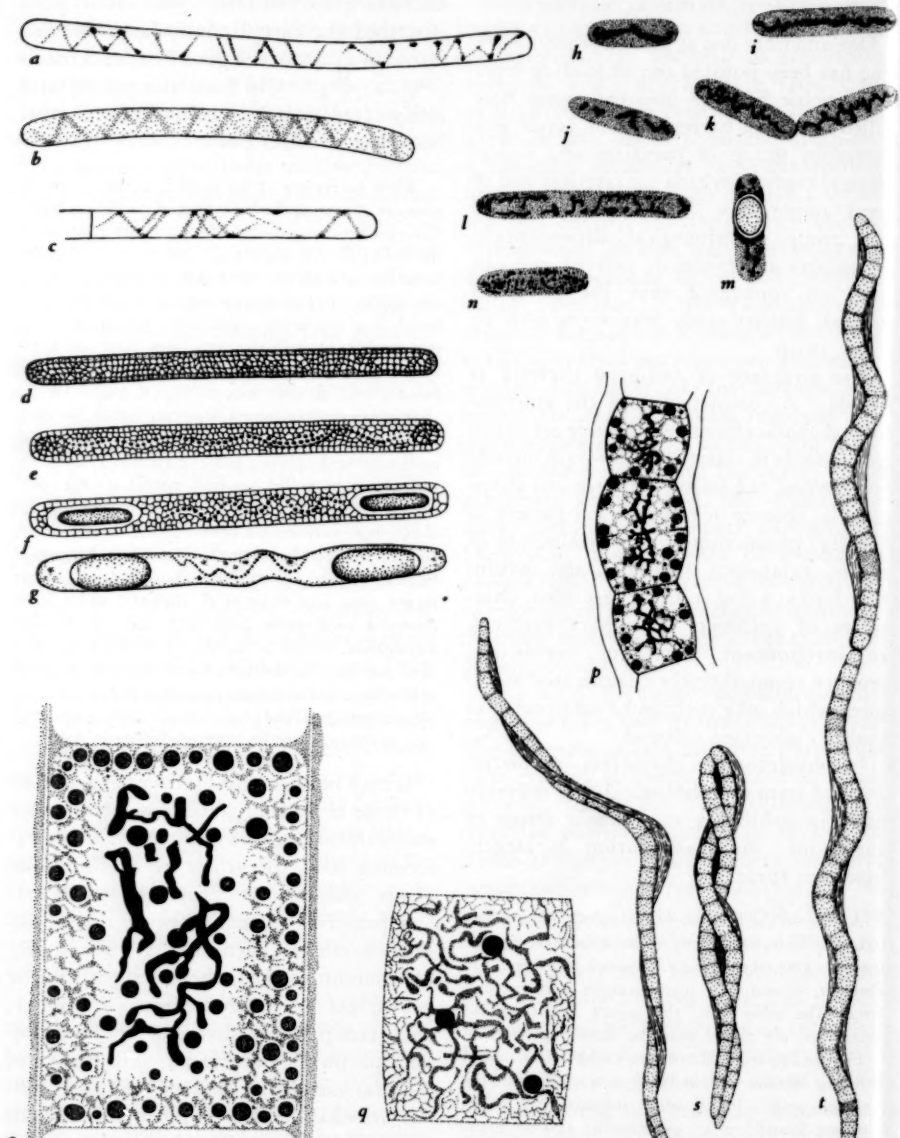

FIG. 1. CYTOLOGY OF MONERA

a–c, *Bacillus maximus buccalis*, after Swellengrebel; d–g, *Bacillus Bütschlii*, after Schaudinn, × 1000; h–n, *Bacillus Saccobranchi*, after Dobell, × 2000; o, *Symploca Muscorum*, after Gardner; p, *Anabaena circinnalis*, after upt, × 2000; q, *Beggiatoa archnoidea*, after Gardner; r–t, *Cristispira Veneris*, after Dobell, × 2000.

an active part in cell division or in spore formation.

MONERA: III. SPIROCHAETS

Spirochaets (the genus *Spirochaeta* and its allies) were first distinguished by Ehrenberg. They include small forms which may be saprophytes in waters, commensals in the alimentary tract of animals (as in the mouth of man and the gut of termites), or parasites in blood, and larger forms of which the most familiar are parasites in mollusks. The group became an object of intense study when Schaudinn showed that one of the species is the cause of syphilis. The character of the group is a spiral body which is flexible. It is a small group, but is so distinct that it must be treated as one of the main groups of Monera.

The cytology is most definitely known in the large forms from mollusks; I describe it primarily from Dobell's account of *Cristispira Veneris* (35; Fig. 1, r–t). The body bears a longitudinal membrane. Internally, it is divided into a series of chambers; if one compares it with filaments of *Spirulina* and *Arthrospira*, one may become uncertain whether it is the whole body or each separate chamber that is to be regarded as a cell. At the margin of each septum between chambers, there is a whorl of granules which stain like chromatin; Dobell interprets these, collectively, as a nucleus. Cell division is transverse; but there is a stage of division during which the two parts of the dividing cell lie side by side; as the free ends separate, they give a false appearance of lengthwise division.

It has been suggested that the spirochaets are related to the trypanosomes, which also inhabit blood and have flexible bodies and lengthwise membranes. This hypothesis served the proper function of hypotheses, that of stimulating investigation, but it should have been abandoned by 1910, when it had become evident that the resemblance extends to no features beyond the ones just stated.

MONERA: IV. BLUE-GREEN ALGAE

Blue-green algae (Myxophyceae Stizenberger 1860; Cyanophyceae Sachs 1874; Schizophyceae Cohn 1879; cf. Setchell and Gardner 104)) are the Monera which possess chlorophyll and live by photosynthesis. They are as common as dirt; they have long been known, but were only gradually recognized, during the latter half of the nineteenth century, as being quite distinct from green algae. As the group is distinguished by positive characters, it is probably natural. It is apparently very ancient; certain species now living build calcareous masses in hot springs, and calcareous masses of similar character are known from the Proterozoic and Archeozoic. I have shown reason, however, for regarding blue-green algae as less primitive than the nitrifying and sulfur oxidizing organisms, and for supposing that they are descended from the latter through the purple bacteria.

The following account of the cytology of blue-green algae is based primarily on the work of Haupt (52; see Fig. 1, p), with consideration of the older accounts of Bütschli (10), Gardner (40; see Fig. 1, o), and Swellengrebel (112).

When cells are studied without sectioning, a central body is evident; sectioning, however, shows that the finely vacuolate protoplasm is uniform throughout the cell. The outer part is distinguished by the presence of pigment in the vacuoles, the inner by the presence of rods and granules, staining like chromatin, imbedded in the protoplasm. The inner part contains also granules which stain red with methylene blue. Gardner calls these "α-granules". They are evidently the same as the "red granules of Bütschli" or metachromatic granules known also from *Beggiatoa*, many ordinary bacteria, and various other organisms. As the cell divides by constriction, the inner part is divided; the rods and granules may be divided, and are distributed at random to the daughter cells.

The above evidence may justify the position (tentative as all scientific con-

clusions are, yet maintained with confidence) that bacteria and blue-green algae are a natural group, being the forms in which life, since its origin, has undergone least change; that they are distinguishable by lack of nuclei; and that they should be treated taxonomically as a kingdom named Monera.

NUCLEATE ORGANISMS

In all organisms except the Monera, the life of every cell is conditioned by the presence within it of one or more nuclei. The nucleus is a part of the protoplast set apart (at least when it is not dividing) by a membrane. Its most definite character is the process, mitosis or karyokinesis, by which it divides into two. During this process a part of the contents (the chromatin) becomes organized as a definite number of definite bodies called chromosomes, each of which is divided into two parts which are distributed respectively to the two daughter nuclei.

Occasionally, nuclei are found to divide by constriction, without going through the mitotic process. Nuclei formed by definitely non-mitotic divisions are unable to persist without limit; sooner or later, such nuclei always decompose and disappear. Non-mitotic division, either binary or multiple (in the latter form called "formation of chromidia") was formerly supposed to be the normal process in various unicellular organisms, especially certain rhizopods. This has been disproved by Kofoid (70) and his associates.

Typical and durable nuclei can originate not only by division, but also by certain fusions of nuclei, always of just two nuclei, which can differ in their heredity only in minor details. Such fusion is the essential feature of sexual reproduction. It gives rise to diploid stages, stages in which each nucleus has a double set of chromosomes; a life cycle in which it occurs must also exhibit at some point a modification of mitosis called reduction division, or meiosis, in which the chromosomes separate into two groups without splitting lengthwise, so that the original or haploid chromosome number is restored. For reasons which are not clear, the reduction division is usually associated with one or more other nuclear divisions which seem to be essentially ordinary mitotic divisions. In the great majority of nucleate organisms, reduction division is followed by just one other division, so that the whole process yields four haploid nuclei.

The uniformity of mitosis; and, if one denies sexual reproduction as a primitive function of the nucleus, then the capacity of the nucleus to assume identical sexual behavior in groups as diverse as men and diatoms, wheat and wheat rust; furnish evidence that the nucleus has come into existence only once in evolution; that all nucleate organisms are related and constitute a natural group, a super-kingdom. The oldest known remains of nucleate organisms are from the late Proterozoic; they represent Radiolaria, sponges, Foraminifera, and even, apparently, worms. None of these groups can be regarded as including the original form of nucleate life. In attempting to date the origin of the nucleus, one must allow time for the evolution of these groups, perhaps the full length of the Proterozoic, back to a billion years ago. No remains of nucleate organisms older than the groups just mentioned are to be expected. Knowledge of the origin and early evolution of nucleate life must be obtained, if it can be obtained at all, by study of races which survive.

Among living organisms, the overwhelming majority of macroscopic forms are properly listed, on the basis of relationship, in the kingdoms of plants and animals. Among microscopic organisms likewise many, as rotifers, nematodes, and

green algae, are legitimate plants or animals. But many microscopic, and a number of macroscopic, organisms fall into groups which cannot confidently be assumed to be descended from any form which would properly be regarded as either a plant or an animal. One of the objects of this paper is to show that these groups should be treated as an additional kingdom: that they form, if taken together, a natural group, having the original nucleate organism as a common ancestor; and that it is more convenient to maintain this group as a taxonomic entity than to make certain other arrangements which would also be consistent with natural classification.

THE APPLICATION OF THE NAME PROTISTA

The groups which, as here proposed, are to constitute a separate kingdom are those which zoologists treat as Protozoa together with the diatoms, the marine algae, and the Fungi. Before they are considered in detail, it will be expedient to show that Protista is the proper name for the combined group.

Protista is the oldest name after Plantae and Animalia to be published as that of a kingdom. As already mentioned, it was published by Haeckel in his *Generelle Morphologie*, in 1866. The views on classification presented in this work were summarized in a figure which is here reproduced (Fig. 2). The figure is a phylogenetic tree; in fact, it is the original phylogenetic tree, of which all others are modifications. Haeckel was the first to use this familiar device for representing the relationships of taxonomic groups.

The figure is seen to represent three kingdoms. The animal kingdom is arranged as it was understood at the time, except that the sponges and the unicellular "animacules" have been excluded; the Infusoria, however, are not yet recognized as unicellular and are placed among the worms. In the plant kingdom, the new name Archephyta is coined for Chlorophyceae, among which, according to the knowledge of the time, the blue-green algae are included. Red and brown algae are present; so are the Fungi, combined with Lichenes under the name Inophyta. At the summit of the plant kingdom stand the bryophytes and vascular plants, arranged in quite modern fashion.

In the third kingdom, Protista, are the flagellates with *Noctiluca* sharply separated from the others; the diatoms; and the sponges, to which the specialist on marine life has devoted a space out of proportion to their significance. Sporozoa are represented by the gregarines, which are included with certain other organisms in a group called Protoplasta. Aside from these groups, practically all of Haeckel's original Protista are or have subsequently been included in Rhizopoda. This is true of the Myxomycetes; of the Protoplasta, excepting the gregarines; and of the Monera, excepting *Vibrio*.

For the purpose of applying the name Protista, it is desirable to recognize a nomenclatorial type. As we ascend the tree, the first name encountered is that of *Vibrio*, the representative of the bacteria. Since it is clear that Haeckel was but poorly acquainted with bacteria, we would be anchoring the name Protista in a fashion which he could not have intended if we should select *Vibrio* as the type. I think that we may safely select as type of Protista the zoologists' standard example of a rhizopod, the organism commonly known as *Amoeba Proteus* Leidy (for an unusually fine example of the nomenclatorial tangle which can be woven about a familiar species, see the references to this species in the papers of Boeck and Stiles (7) and Schaeffer (100)).

Haeckel's life work subsequent to the

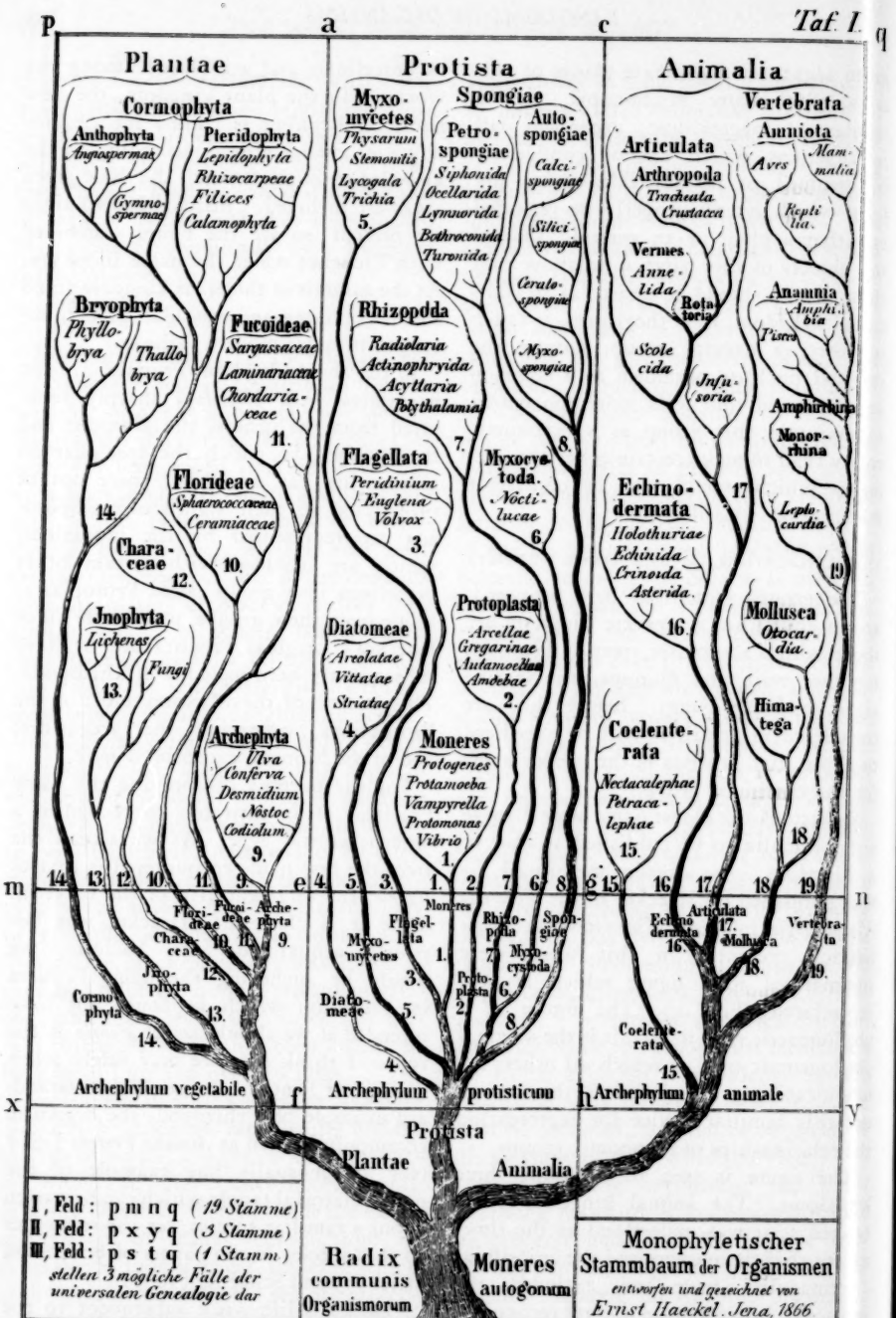

FIG. 2. REPRODUCTION OF PLATE I FROM HAECKEL'S "GENERELLE MORPHOLOGIE," VOLUME 2.

publication of the *Generelle Morphologie* consisted in large part in elaborating and refining the ideas expressed in the phylogenetic tree just discussed. In this original tree, he avoided expressing an opinion as to whether life had originated just once or many times: the three transverse lines in the lower part of the figure indicate three levels at which life might have come into existence. He was sufficiently aware of the significance of the nucleus to set apart a group characterized by its absence; he was not sufficiently aware of it to avoid suggesting that life might repeatedly have come into existence equipped with nuclei. In his *History of Creation* (44) he suggested the multiple origin of life and the development of nuclei in several distinct lines. In his late work *The Wonders of Life* (45) he avoided the question by presenting a manifestly artificial "morphological classification" essentially as in the attached table (Table 1).

TABLE 1

Haeckel's "Morphological Classification" (1904)

	"KINGDOM" PROTISTA, (UNICELLULAR ORGANISMS)		"KINGDOM" HISTONA, (MULTICELLULAR ORGANISMS)
	Monera, organisms without nuclei	Nucleate Protista	
Plants	Blue-green algae	Green flagellates, diatoms, etc.	Metaphyta
Animals	Bacteria	Rhizopoda, Infusoria, etc.	Metazoa

By the history just sketched, the name Protista came to have several connotations in the minds, apparently, both of the one author who maintained the group and the many who rejected it. It was conceived as the group representing the most ancient forms of life; the group distinguished by the unicellular character; the group which lies between plants and animals; the group which is essentially a combination of Monera and Protozoa. The use of nomenclatorial types enables one to overlook the connotations, the conflicting supposed definitions, of the name of a group until after the application of the name is determined. If *Amoeba Proteus* is the type of Protista, then whatever kingdom aside from Plantae or Animalia includes this species must be called Protista. On many occasions the results of applying the type system seem outrageous to established conventional usage, but I do not think this will be found true of the present case. The name Protista is here applied to a group considerably amended since it was set up for flagellates, rhizopods, diatoms, and sponges, but the amendments are no greater than one would expect as a result of seventy years' advance in knowledge of the groups concerned. Most of the original Protista retain their place in the kingdom; the group continues to include the common ancestors of plants and animals; it has the common characters of plants and animals in the nucleus and features dependent on the nucleus; it consists chiefly of unicellar organisms. This application of the name Protista to a particular group is qualified, however, by the condition that the group can be justified as natural and convenient.

PROTISTA: I. PIGMENTED FLAGELLATES

Justification of the group involves an enumeration of the subsidiary groups, with a consideration of the origin and characters of each. This survey should begin with the most primitive of nucleate

organisms. We cannot as yet recognize, either among living organisms or among fossils, a series connecting Monera with nucleate organisms, nor any very limited race which was the first to possess a nucleus. We can, however, reconstruct to a considerable extent the characters of the original nucleate organism and we can place it in a certain major group of existing organisms.

The original nucleate organism must have been unicellular rather than multicellular, and autotrophic rather than dependent. All autotrophic nucleate organisms live by photosynthesis. As photosynthesis occurs in certain Monera, we may be confident that this function was inherited from Monera by the original nucleate organism. The photosynthetic pigments in nucleate organisms are always confined to certain organelles called plastids. These do not occur in Monera; they were evidently evolved more or less concurrently with the nucleus.

Nucleate unicellular organisms living by photosynthesis are included in the natural groups (commonly construed as orders) called chrysomonads, Heterokontae, cryptomonads, dinoflagellates, chloromonads, and euglenids. (Other organisms with these characters are included among diatoms and green algae; these two groups are evidently derived, and need not be considered in the present connection.)

In the six groups just listed, the typical members are motile by means of flagella. Several if not all of them include, however, forms which lack either or both the characters of flagellation and pigmentation; there are colorless flagellate forms, amoeboid forms, and stationary forms which may be either unicellular, colonial, or filamentous. The amoeboid character appears to be an adaptation for holozoic nutrition, that is, for the ingestion of solid food. It is almost always associated with loss of pigmentation and is obviously a derived condition. The colorless flagellate forms and the colonies and filaments are likewise obviously derived. As to whether possession of flagella is a primitive character in these groups, we may reach a conclusion by considering the alternatives, that flagella of essentially identical character (there are differences in detail, as pointed out by Deflandre (32)) have been developed independently in all six groups, or, on the other hand, that they are inherited from a common ancestor of all six groups, and that the non-motile forms are derived. The latter alternative is surely the sound one. Fagella, like the function photosynthesis, appear to be an inheritance from Monera, and to have been characters of the first organisms that developed nuclei and plastids.

It appears, then, that all organisms which are at the same time nucleate, unicellular, flagellate, and capable of photosynthesis constitute a natural group. It is, however, not expedient to recognize a taxonomic group limited by these characters. In the taxonomic system, as we have seen, organisms as just described are distributed among six groups (or, counting green algae, seven), and to each of these groups are admitted organisms lacking flagella or photosynthetic pigments, or forming bodies of more than one cell. These groups are distinguished by differences in the pattern of flagellation, in the particular pigments present, in storage products, in materials and structure of walls or shells, and in other features. It has been possible only to a very limited extent to show that some of them are derived from others. The chrysomonads are generally supposed to be the most primitive, and Pascher (93, 96) has shown that the Heterokontae (also the diatoms) are related to, and presumably derived from, these. It is evident from the isolation of these groups that they are very ancient, and some authorities have been disposed to raise them to very high taxonomic rank. It is also evident, however, that the six groups taken together are still a natural group, being essentially the sub-class Phytomastigina of zoologists, the division Chrysophyceae of Tilden

(115). All other nucleate organisms may be regarded as derived from this group.

In dealing further with the evolution and groups of nucleate organisms, features of the nucleus will be found significant. Although essentially uniform, the nucleus varies in details; the variations fall into more or less parallel evolutionary lines in the various groups. For the sake of having a definite conception of the starting point of these lines, we need much more knowledge than we have of the nuclei of the pigmented flagellates. In particular, the supposedly primitive chrysomonads are poorly known.

There have been a considerable number of accounts of nuclear structure and behavior among the euglenids. Early observations of *Euglena* revealed a large intranuclear body which divides during mitosis and seems to lead the chromosomes in separating. This body was designated a nucleolo-centrosome; we may for the present call it by the term endosome, which implies an internal body without specifying its nature. Modern work on *Euglena agilis* by Baker (2) and on *Euglena Spirogyra* by Ratcliffe (98; Fig. 3) has shown that the endosome, some time before nuclear division, buds off a body which moves to just within the nuclear membrane and divides.

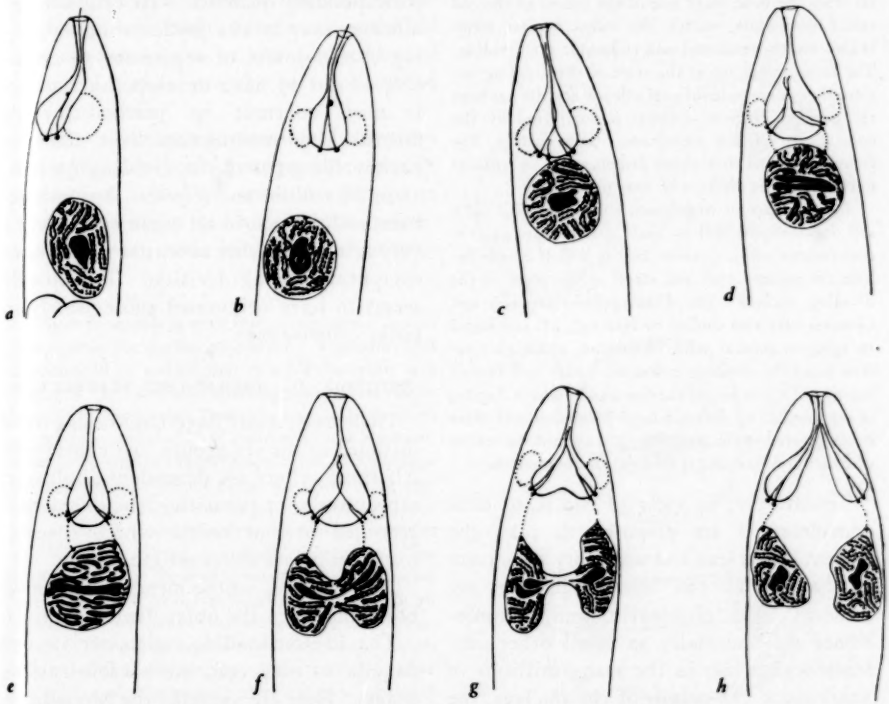

FIG. 3. NUCLEAR DIVISION IN EUGLENA SPIROGYRA, AFTER RATCLIFFE, × 720

The term centrosome may be applied to this body and to the two bodies formed by its division rather than to the endosome. As division begins, the nucleus moves forward within the cell and comes into

contact with the cell membrane in the bottom of a depression at the forward end. Each centrosome seems to generate, just within the adjacent cell membrane, a body called a blepharoplast; the nucleus then withdraws from the cell membrane, leaving the centrosomes connected to the blepharoplasts through fibers called rhizoplasts. In *Euglena Spirogyra* (the details are different in *E. agilis*) the flagellum, which is attached within the reservoir and already forked at the base, splits lengthwise; a new flagellum grows out from each blepharoplast and becomes fused, not far from the base, with one of the halves of the old one. Meanwhile, within the intact nuclear membrane, the chromosomes and endosome are dividing. The centrosomes are at the sides of the dividing nucleus, not at the poles of a spindle; no spindle has been recognized. Nuclear division is completed by the constriction of the membrane. Subsequently, the centrosomes and rhizoplasts disappear, to be replaced during the next division by new ones.

In the euglenids *Menoidium*, studied by Hall (46), and *Peranema*, studied by Hall and Powell (49) the centrosomes are permanent bodies which divide before the nucleus does and stand at the poles of the dividing nucleus. The dinoflagellates *Oxyrrhis* and *Ceratium* were also studied by Hall (47, 48) and found to agree in general with *Menoidium*, although *Ceratium* lacks the dividing endosome. Hall and Powell are unwilling to accept the features in which *Euglena* is supposed to be different from *Menoidium* and these other genera but the essential agreement of the results of Baker and Ratcliffe is evidence of their accuracy.

Tentatively, in view of the scant data considered, I am disposed to take the system of nucleus and accessory structures in *Euglena* as the most primitive yet known. The chromatin and chromosomes are essentially as in all other nucleate organisms; in the many millions of years since the origin of the nucleus, the chromatin of different organisms has acquired the power of transmitting a bewildering variety of hereditary qualities, but the only visible changes have been fluctuating variations in its arrangement in the resting nucleus, and in the number, size, and shape of chromosomes. The centrosome would appear to be originally a device for the production of flagella, related to mitosis only in that mitosis makes new flagella necessary. The endosome, although it gives rise to centrosomes, is not in itself a centrosome or a nucleolo-centrosome, but it may yet be a nucleolus. The nuclear membrane and nuclear sap, which disappear during division in the nuclei of higher organisms, are here permanent structures, persisting through division and being divided, and the endosome may be a nucleolus with corresponding qualities. Its original significance may be as a guide to the separating chromosomes of organisms so primitive as not to have developed a spindle. It may continue to persist through mitosis after centrosomes have come to occupy the poles of the dividing nucleus, as in *Menoidium* and *Oxyrrhis*, but in *Ceratium*, and, in fact, in all organisms except a very few, it is either absent at all times or disappears during division. The spindle seems to have originated subsequently to polar centrosomes.

PROTISTA: II. ANIMAL-LIKE FLAGELLATES

There exist many flagellates beside those included in the six groups just considered. All these others are dependent (holozoic, saprophytic, or parasitic); they have been arranged in four orders which togethe form a subclass Zoomastigina.

A few genera whose members are amoeboid constitute the order Pantostomatida.

The Protomonadida, with one or two flagella to each cell, are a varied assemblage. Here are included the Monadidae, the genera of which, as Pascher (94, 95) has shown, would be naturally placed by distributing them among the chrysomonads. Here also are included the trypanosomes—parasites in the blood stream of animals, the most intensively studied of all flagellates—and the choanoflagellates or collared monads, of interest because cells of similar structure are an element in the bodies of sponges.

The Polymastigida have three to eight

flagella per cell (per nucleus, in certain races with multinucleate cells); the Hypermastigida have more than eight flagella per cell. The members of these groups are largely entozoic; the Hypermastigida are confined to insects, particularly termites. They are notable for elaboration of the systems of structures (neuromotor systems) which extend from the nuclei to the flagella and other parts of the cell. Cytologically, as a result of the work of Kofoid and his associates at the University of California, these are the best understood of flagellates.

Kirby's (67) reorganization of the polymastigote family Trichomonadidae gives a convenient view of some of the parts which may make up a neuromotor system, together with some hints as to their evolution.

There is usually a permanent centrosome located just outside the nuclear membrane. Typically, this is connected by a rhizoplast to a blepharoplast or a cluster of blepharoplasts standing near the cell membrane. In *Trichomitus Termitidis* a single body is regarded as a combination of centrosome and blepharoplasts, although one might suspect that by homology it represents only one of them, the other being suppressed. The Hypermastigida, incidentally, although not directly related to *Trichomitus*, resemble this form in having a centroblepharoplast. The blepharoplast or centroblepharoplast, as the case may be, bears several free flagella together with an internal rod which is called the axostyle and is suspected of being homologous with a flagellum. Laterally attached to the blepharoplasts there is in some examples a darkly-staining mass called a parabasal body. One flagellum is usually reversed, trailing behind the cell as it swims; in *Trichomonas* and its immediate allies, this is grown fast to the cell, forming an undulating membrane. Concurrent with the evolution of the undulating membrane has been the evolution of an internal rod attached to a blepharoplast and serving apparently as a mechanical support to the undulating membrane. Kirby, distinguishing this from both the axostyle and the parabasal body, names it the costa.

The features of mitosis in Polymastigida and Hypermastigida may be illustrated by a comparatively simple, and in this respect presumably primitive example, namely, *Trichomonas buccalis* as studied by Hinshaw (54; see Fig. 4). The centrosome, blepharoplast, and rhizoplast divide; the centrosomes remain connected to one another, for

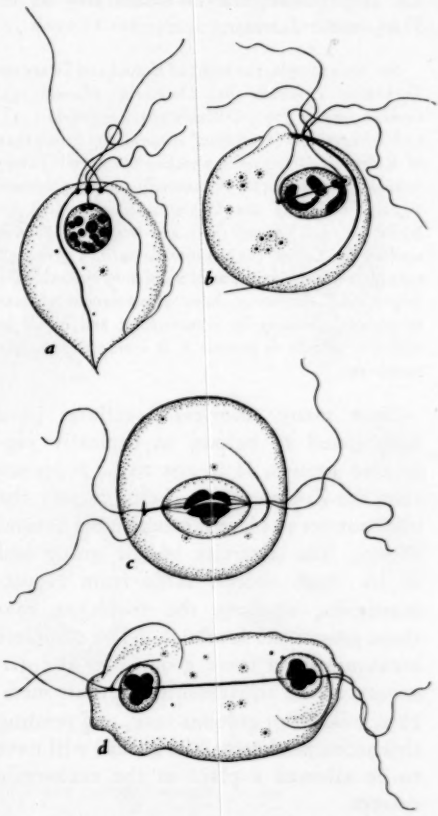

FIG. 4. NUCLEAR DIVISION IN TRICHOMONAS BUCCALIS, AFTER HINSHAW, × 4000

a time, by a fiber called the paradesmose. There is no dividing endosome. A spindle is formed within the nuclear membrane between the centrosomes. The nuclear membrane does not disappear; after the chromosomes have separated, it divides

by constriction. The free flagella are divided between the two daughter cells, each of which regenerates the parts of a complete cell which it has not inherited.

Although showing much variation, and in some examples much elaboration, the mitotic process in most Polymastigida and all Hypermastigida is essentially as in *Trichomonas buccalis*.

See, for example, the work of Kofoid and Swezy on *Trichomitus Termitidis* (72), *Chilomastix Mesnili* (75), *Giardia enterica* (77), *Trichonympha Campanula* (73), and *Trichonympha (Leidyopsis) sphaerica* (74); also that of Kirby on *Dinenympha fimbriata* (62), and *Staurojoenina assimilis* (63). A minority of the polymastigotes, including the Oxymonadidae studied by Kirby (65) and Connell (20), and *Streblomastix Strix*, studied by Kidder (61), show deviations profound enough to seem significant of a different evolutionary origin. All, however, have a permanent nuclear membrane, dividing by constriction; and in all in which a spindle is present it is inside the nuclear membrane.

Since many colorless flagellates have been found to belong to typically pigmented groups, it is not to be supposed that the Zoomastigina, being merely the ones not yet so placed, constitute a natural group. The diversity of the group and of its three orders, aside from Hypermastigida, confirms the suspicion that these groups are artificial. The complete breaking up of these groups, by the discovery of the relationships of their members, will be an arduous task, and pending this accomplishment, the groups will have to be allowed a place in the taxonomic system.

PROTISTA: III. DIATOMS

The diatoms are a numerous group of unicellular (less commonly colonial or filamentous) organisms with brown plastids. They have finely, elaborately, and characteristically sculptured shells of silica; the shell of each cell consists of two parts fitting over each other, as the textbooks say, like the parts of a pill-box. The cells may be non-motile, or motile by means of flowing bands of protoplasm which function like endless belts.

The existence of sexual reproduction in the groups just treated as flagellates is questionable; in diatoms it is positively established. Reduction division takes place immediately before the sexual fusion of nuclei; this means that all nuclei of diatoms, except those formed for the purpose of sexual fusion, are diploid. This is a character of groups in which sexual reproduction is ancient and presumably inherited from pre-existing groups; it strengthens the impression made by the other characters of diatoms, that this is a derived, highly specialized group.

Nuclear division in diatoms is best known by the old work of Lauterborn (83). His results, puzzling in many details, were confirmed in most respects by Karsten (58). There is a centrosome at the nuclear membrane (apparently outside). This buds off a ring-shaped structure which enters into the nucleus and by growth becomes a tube extending clear through it. The nuclear membrane disappears early in mitosis, but the nuclear sap remains for a time distinct from the cytoplasm. The chromosomes gather in a mass at the middle of the tubular structure; they then divide into two doughnut-shaped masses which travel to the ends of it. As these masses become organized into new nuclei, the cytoplasm seems to absorb the nuclear sap, and likewise the tubular structure, but not until the latter has budded off a new centrosome from each end.

Lauterborn and Karsten interpreted the tubular structure, in terms of the knowledge of their time, as a central spindle. It seems possible, however, that this structure represents a chromatin-dividing appa-

ratus more ancient than any sort of spindle; perhaps it is homologous with the dividing endosome of the euglenids. Pascher, as already mentioned, has shown that the diatoms are related to the chrysomonads. A confident interpretation of the mitotic process just described will depend on an understanding, yet to be obtained, of the chrysomonads.

The brown algae (Melanophyceae Stizenberger 1860; Phaeophyceae Kjellmann 1891; cf. Setchell and Gardner (104)) show an evolution from filamentous forms with a life cycle of similar haploid and diploid stages to thalloid forms with a considerable differentiation of organs and tissues, and whose haploid stages are reduced to the mere gametes. They produce

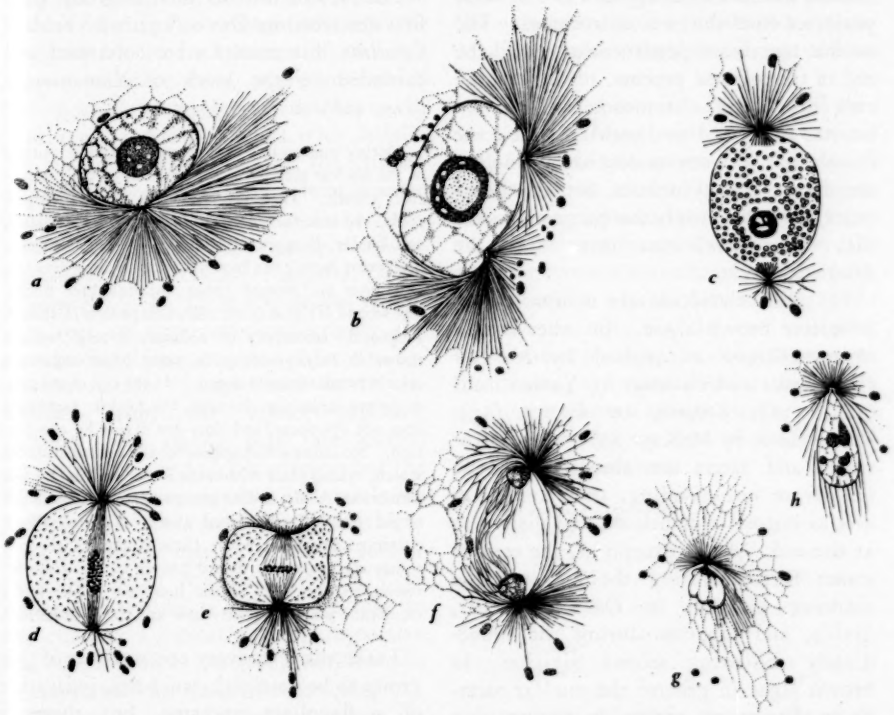

FIG. 5. NUCLEAR DIVISION IN STYPOCAULON, AFTER SWINGLE, × 800

PROTISTA: IV, V. MARINE ALGAE

The two great groups of marine algae consist of multicellular organisms, some of which are exceedingly large; they live by photosynthesis and have plastids of other colors than green; they produce no true starch or cellulose. Beyond these characters, they have little in common; they are not closely related.

flagellate reproductive cells, each bearing two laterally attached unequal flagella; these cells are so small that the presence of any structures connecting the nuclei with the flagella is doubtful.

In Sphacelariaceae, among which Swingle (113) studied particularly *Stypocaulon* (see Fig. 5) there is a permanent centrosome located just outside the membrane of

each nucleus. It stands at the focus of an aster, a mass of fibers radiating into the cytoplasm; such a structure is found in many groups, including diatoms but apparently not flagellates. Before each nuclear division, the centrosome and aster divide into two, which move apart along the membrane to opposite sides of the nucleus. A spindle forms within the nuclear membrane; it appears as if it were projected from the two centrosomes. The nuclear membrane persists nearly until the end of the mitotic process. Then, as the two groups of chromosomes begin to become organized as daughter nuclei, the distinction between nuclear sap inside the membrane and cytoplasm outside disappears, and the membrane becomes invisible. New membranes form about the daughter nuclei.

The Sphacelariaceae are comparatively primitive brown algae. In other brown algae—*Dictyota* as studied by Mottier (91); *Fucus* and *Cutleria*, by Yamanouchi (129, 130); *Zonaria*, by Haupt (53); *Pterygophora*, by McKay (89)— the centrosomes and asters are absent when the nuclei are not dividing; they appear *de nove* as mitosis commences, and disappear at the end. As an exception, the centrosomes formed during the first or true reducing division in *Dictyota* persist, divide, and function during the immediately following second division. In brown algae in general the nuclear membrane disappears earlier in the mitotic process than it does in *Stypocaulon*.

The descent of brown algae from flagellates is evident. The possession of centrosomes is probably related to the production of flagellate reproductive cells. But those who have studied the groups most closely are unwilling to connect the brown algae with any particular group of flagellates.

The red algae, Rhodophyceae, include certain poorly known organisms of comparatively simple organization; but most of the very large number of species are of complicated structure and exhibit complicated reproductive processes. They produce no motile cells whatever. The cell walls are of a pectinaceous material which appears in commerce in the diverse forms of agar-agar and edible birds' nests.

Features of mitosis in this group were first described by Davis (29), who studied *Corallina;* his results were confirmed and extended by the work of Yamanouchi (127, 128) on *Polysiphonia*.

During most mitoses, centrosomes appear outside of the nuclear membrane at the poles of the intranuclear spindle. There are no asters. As mitosis proceeds, the centrosomes swell, become less stainable, and finally disappear. The old nuclear membrane disappears during the later stages of nuclear division; new ones are formed about the daughter nuclei. The second division of the reduction process, although supposedly essentially an ordinary mitotic process, shows in *Polysiphonia* as in many other organisms certain peculiarities in detail. At the end of the first, or proper, reduction division, the nuclear membrane does not disappear, and does not divide by constriction. No centrosomes appear for the second division, which, taking place within the intact original nuclear membrane, results in four groups of chromosomes in a single tetrahedrally lobed space. The membrane continues to persist where these clumps of chromosomes are against it, but dissolves in the areas between, so that each of the four new nuclei has a membrane which is partly new and partly inherited.

I take the temporary centrosomes of this group to be vestigial structures, indicative of a flagellate ancestry, but there is nothing to connect the red algae with any particular group of flagellates; they are an advanced and highly isolated group.

PROTISTA: VI, VII. RHIZOPODA AND SPOROZOA

The Rhizopoda are nucleate organisms with exposed protoplasm which can be thrust forth in projections called pseudopods. As authority for the name, Siebold,

1845, is cited; Sarcodina of Hertwig and Loesser, 1874 (cf. Stiles and Hassall (110)), was intended to apply to a larger group including this, but must be regarded as a synonym. These organisms were formerly regarded as representative of the starting point of life, and hence as being automatically a natural group. The positive evidence for these views, in the supposed formation of nuclei *de novo* from chromidia, has been discredited; and the evidently derived character of the few known self-nourishing organisms which are amoeboid is convincing evidence to the contrary. Amoeboid forms with flagella are placed naturally among the chrysomonads (*Chrysapsis*) and Heterokontae (*Chloramoeba*); others are conventionally stationed among the Zoomastigina (*Mastigamoeba*) and Sarcodina (*Naegleria*, *Trimastigamoeba*). It will be convenient to call this sort of organisms collectively the amoebo-flagellate complex. Many recognizable natural groups seem to be descended from the amoebo-flagellate complex, and among them are several which are assigned to Rhizopoda; but the Rhizopoda taken together are clearly an artificiality. As various lines of rhizopods have come into existence by loss of characters from organisms which were themselves simple, it will not be easy to find characters indicating their respective true relationships; the group will have to be maintained for some time to come.

The groups included here as orders are Lobosa, Foraminifera, Heliozoa, Radiolaria, and Myxomycetes. All of them appear to be natural except the first. The Foraminifera and Radiolaria, having shells suitable for preservation as fossils, are known to be very ancient, as we might expect in groups having no assignable nucleate ancestors except flagellates.

The best known cytologically, of Rhizopoda as of Zoomastigina, are the entozoic species studied by Kofoid and his associates. The scientists of the California school were not the first to describe a normal mitotic process in amoebas, but in a long series of papers (16, 60, 64, 71, 76, 78, 79, 80, 124) they have shown that typical mitosis is typical of the group. In the resting nucleus, the chromatin is largely or entirely gathered into a single mass called a karyosome. A centrosome, the only remnant of a neuromotor apparatus, is found during mitosis just within the persistent nuclear membrane; it divides, and the parts remain connected by a fiber which, being within the nucleus, is called an intradesmose. A spindle is present; Child (16; see Fig. 6), working on *Endamoeba gingivalis*, found that it forms before the centrosome divides, extending from the centrosome in among the chromosomes which have formed from the karyosome; later, as the two daughter centrosomes move apart along the nuclear membrane, it opens like a jack-knife opening, to form a straight line.

The following are some of the observed chromosome numbers:

Councilmania Decumani	4
C. dissimilis	8
C. Lafleuri	8
C. Muris	6
Endamoeba coli	6
E. dysenteriae	6
E. disparita	12
E. gingivalis	6

In the "*Vahlkampfia* group" the chromosomes are smaller and more numerous, and there are prominent polar caps of stainable material within the dividing nucleus. These polar caps, mistaken for separating masses of chromatin, are largely responsible for the reports of non-mitotic division in amoebas. Within these caps, Kofoid and Swezy (79) first discovered centrosomes in *Karyamoebina falcata*.

In the amoebo-flagellate *Naegleria*,

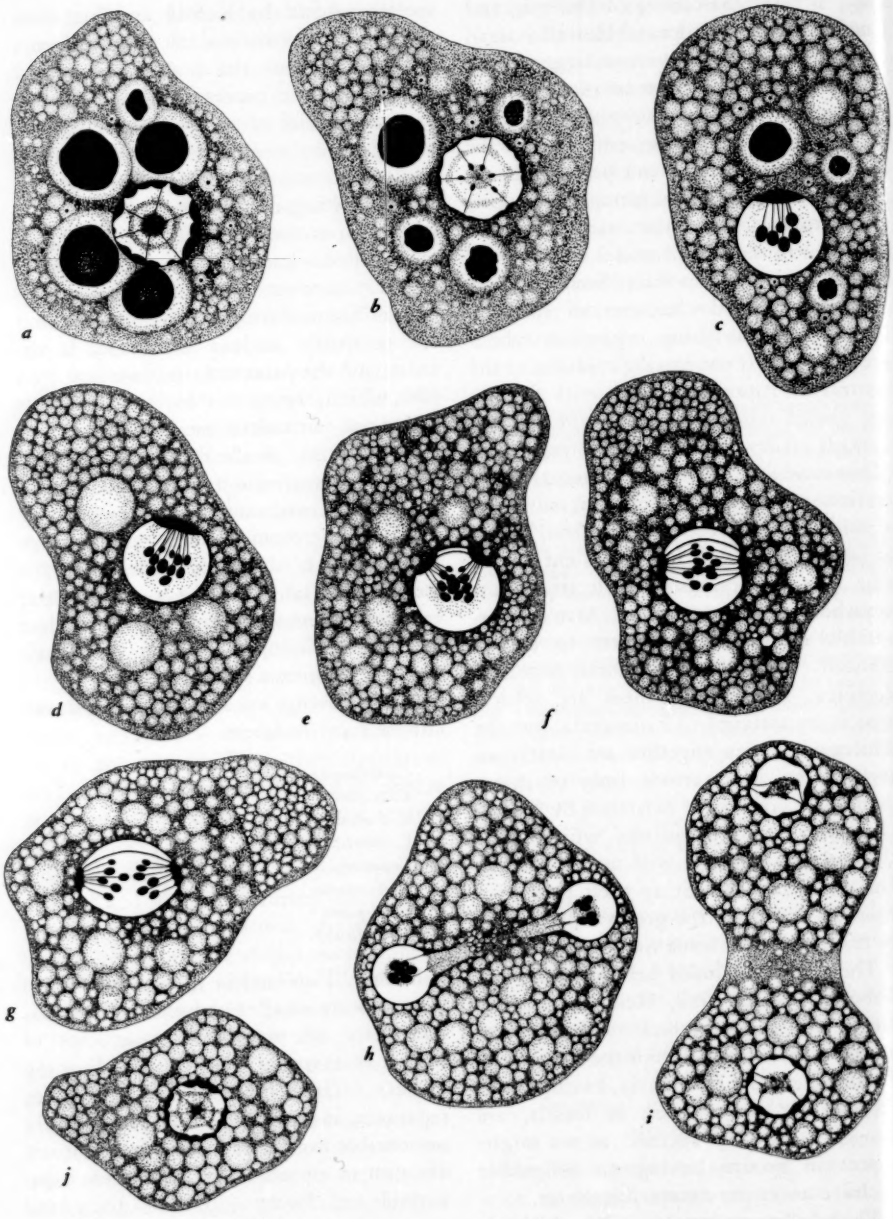

FIG. 6. NUCLEAR AND CELL DIVISION IN ENDAMOEBA GINGIVALIS, ORIGINAL FIGURES BY H. J. CHILD, × 3750

which is normally amoeboid but readily induced to form a flagellum, Wilson (124) found that mitosis is of the *Vahlkampfia* type. When the flagellum is present, a rhizoplast connects the blepharoplast to the intranuclear centrosome, and another connects this to the karyosome. The extra-nuclear neuromotor apparatus—all of the neuromotor apparatus except the centrosome—is discarded or absorbed before division; it is regenerated from the centrosome, and Wilson was disposed to believe that this emerges from the karyosome.

The Myxomycetes will be considered separately.

The Sporozoa will merely be mentioned. The group includes very many species, all parasitic in animals. They have complicated life cycles, involving sexual reproduction; they are ordinarily non-motile, but have flagellate or amoeboid stages, indicating descent from the amoeboflagellate complex. They are apparently not a natural group. *Monocystis* was found by Calkins and Bowling (12) to have an extra-nuclear centrosome. This divides during the early stages of mitosis, and a spindle is formed between the daughter centrosomes; the nuclear membrane dissolves, and the spindle is carried laterally in among the chromosomes. The process is very much as in animals.

PROTISTA: VI A. MYXOMYCETES

The Myxomycetes were so named, as a group of Fungi, by Link, 1833. Some twenty-five years later de Bary, recognizing their resemblance to rhizopods, named the Mycetozoa (cf. Macbride and Martin (85)). In their vegetative condition, Myxomycetes are colossal amoebas adapted to life in air; the plasmodium, as the vegetative stage is called, is a naked mass of protoplasm containing thousands of nuclei, moving pseudopodially, and nourishing itself in holozoic fashion. Plasmodia are inconspicuous only because they keep to damp and shaded habitats. In reproduction, the protoplasm builds more or less elaborate structures by secreting pillars, fibers, and walls, of lifeless material, among which it undergoes cleavage into little spores homologous with the cysts of other rhizopods. The germinating spores release amoeboid cells which presently develop flagella.

The nuclei are minute, and the authors who have attempted to study them have found difficulty in recognizing nuclear division in the plasmodium. Just previous to spore formation, and again when the spores are germinating, mitoses are recognizable (see Harper (51) on *Fuligo;* Jahn (56) on *Stemonitis;* Howard (55) on *Physarum;* Gilbert (42) on *Ceratiomyxa*). A sharp-pointed spindle is formed within the nuclear membrane, and definite centrosomes have been recognized at the poles. The nuclear membrane persists for some time, but disappears before the end of mitosis. A nucleolus is present in the resting nucleus, and fades out at about the same time as the nuclear membrane. The nuclear divisions just before spore formation are supposed normally to include a reduction division; in *Ceratiomyxa*, a genus distinguished from other Myxomycetes by a variety of characters, reduction division takes place within the spore, which accordingly becomes 4-nucleate.

Gilbert gives a full description of the formation of flagella in *Ceratiomyxa*.

> The 4-nucleate protoplast escapes from the spore wall; after it has undergone various changes in form, each nucleus divides. While the protoplast is dividing by constriction into eight, each nucleus comes into contact with the cell membrane. The part of each nucleus which comes into contact with the membrane is the part diametrically away from the sister nucleus formed by the preceding division; this is the part where a centrosome, retained since the preceding division, may be presumed to be present. From the

point of contact, a flagellum is suddenly projected beyond the cell membrane; the nucleus then withdraws from the cell membrane and is found to be connected to a blepharoplast at the base of the flagellum by something which looks like a double rhizoplast. The accounts of enflagellation in *Stemonitis* and *Physarum* represent essentially the same process; but Jahn interpreted the structure between the nucleus and the base of the flagellum as a conical region of clear cytoplasm, whose boundaries would appear in optical section as two fibers.

The flagellate cells, in many Myxomycetes if not in all, are gametes; they fuse in pairs. The Myxomycetes are diploid in all stages except spores and gametes. It is not certain whether the amoeboid zygotes can combine with each other in forming the plasmodium, or whether each plasmodium is developed from a single zygote.

The Myxomycetes are evidently a natural group, and are evidently descended from something in the amoebo-flagellate complex.

PROTISTA: VIII. FUNGI

The group called Fungi, as here construed, consists of parasites and saprophytes whose bodies consist of filaments with rigid walls of chitin. They may be arranged in four classes. Two classes, Basidiomycetes and Ascomycetes, are highly developed groups, numerous in species, evidently natural, and showing in their characters some relationship to each other. Zygomycetes are a comparatively small and primitive group, not connected to the others by any forms confidently recognizable as intermediate.

The remaining class, the one usually and properly listed first, is Oomycetes. It embraces a variety of forms so broad that one cannot be positive either that the group is natural or that it is not. The main body of the class, consisting of the orders Saprolegniales and Peronosporales, is a natural group of typical filamentous fungi. They resemble in many respects such green algae as *Vaucheria;* the resemblance is usually taken as indicative of relationship, but is open to interpretation as being a result of parallel evolution.

The order Chytridiales, also included in Oomycetes, has been used as a dumping ground for poorly understood parasites. Here have been placed the intracellular parasites of flagellates, Infusoria, and rhizopods (see Becker (4), Campbell (13), Connell (20), Kirby (66, 68), Kofoid (70), Sassuchin (99)). Some of these, at least, are obvious bacteria. Leaving such things aside, the chytrids can be recognized as having a character of their own. A protoplast, originally naked and flagellate, makes its way into a cell of an alga or higher plant. There it develops a rigid wall, and usually sends out filamentous branches. It becomes multinucleate, and eventually breaks up into naked swimming cells which escape, usually, through a walled tube. Such an organism can be interpreted as a link between the amoebo-flagellate complex and the typically fungal Saprolegniales and Peronosporales.

Mitosis is known in several genera of the latter orders (see Davis (31) on *Saprolegnia;* Couch (26) on *Leptolegnia;* Davis (30) and Stevens (107, 108) on *Albugo;* Stevens (109) on *Sclerospora*). It resembles that of Myxomycetes: the sharp-pointed spindle, at the ends of which centrosomes have been detected, is formed within the nuclear membrane. The membrane persists until about the middle of the mitotic process. The nucleolus is rather persistent, and Stevens has in some cases found it to divide into two parts which pass to the poles of the spindle.

Cotner (24, 25) has described the origin of flagella on the swimming cells of several genera. The nucleus is drawn out into a beak which reaches, or nearly reaches, the cell membrane. From the

beak, the one or two flagella (the number is constant in each genus) are projected; the nucleus then withdraws from the surface of the cell, but remains connected to the blepharoplasts at the bases of the flagella by one or two rhizoplasts. All this is quite as in *Ceratiomyxa*.

The mitotic processes of Oomycetes have been described chiefly from the reproductive structures; the vegetative nuclei in the filaments are too small, and are not easily enough found in division, inside. The centrosome divides, and as the two daughter centrosomes move apart along the nuclear membrane, the ends of the two parts of the spindle swing apart until they form a straight line. The nucleolus disappears; the nuclear membrane persists until the later stages of mitosis, when it seems to dissolve or collapse, leaving each cluster of chromosomes, while shredding out into a network, to develop a new membrane. The centrosomes persist, dividing at each

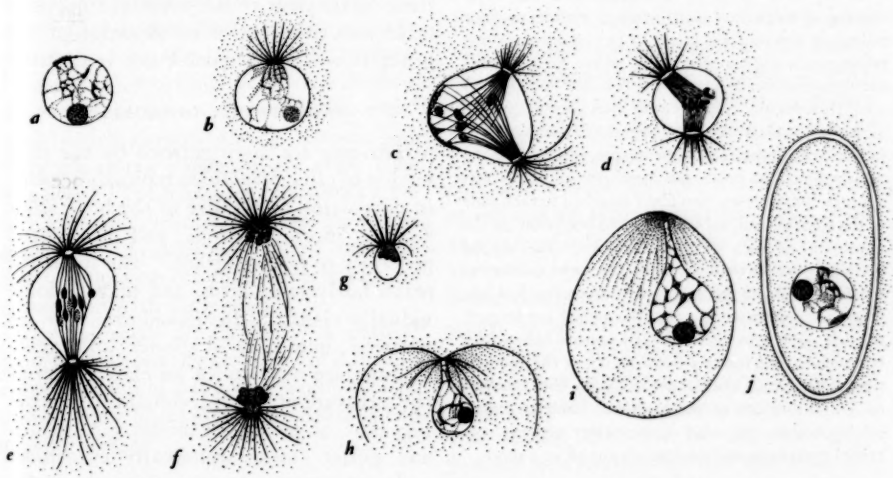

FIG. 7. NUCLEAR DIVISION AND FORMATION OF ASCOSPORES IN ERYSIPHE COMMUNIS, AFTER HARPER

for convenient study. The same situation holds in Ascomycetes and Basidiomycetes. The three nuclear divisions, including the reduction division, which lead to spore formation in Ascomycetes have been described by a long series of authors, who consistently confirm Harper's (50) early account of the process as observed in *Erysiphe* (Fig. 7). A centrosome lying next to the nuclear membrane, apparently fused to its outer surface, develops an aster toward the outside and a bundle of spindle fibers toward the nuclear division; at the end of the last nuclear division, the nuclei thrust them forth on beaks. These beaks, since the spores are dispersed in air, do not generate flagella; instead, they seem to induce the formation of a spore wall some distance out from and surrounding each nucleus.

Many studies of Basidiomycetes, of such diverse groups as mushrooms, puffballs, and rusts, have been carried out with the use of technique refined enough to yield chromosome numbers, which are apparently always two or four. The spindle is

developed within the nuclear membrane, and is sharp-pointed; Lander's (82) figures of *Scleroderma* show definite centrosomes at the poles. The nuclear membrane seems always to disappear early in the mitotic process, though the nuclear sap may remain distinct from the cytoplasm for some time longer.

The spore-producing organ, the basidium, includes one original nucleus which undergoes a reduction process of two divisions.

In *Coprinus*, Vokes (119) describes the nucleus as moving up to the cell wall; when it withdraws, four points on the wall are found to be connected to one point on the nuclear membrane, where we can imagine a centrosome, by four fibers, possibly homologous with rhizoplasts. The point of attachment seems to divide as nuclear division begins. The spindle is formed within the nuclear membrane, with the points of attachment as poles; the membrane presently disappears, but there are two fibers attached to each pole of the spindle, and, subsequently, to one point on the membrane of each daughter nucleus. The second division goes forward in much the same manner as the first; each of the four resulting nuclei has one fiber attached to it. As the four nuclei are formed, the cell wall grows out, at each point where a fiber is attached, and forms a little cavity at the end of a slender tube; each nucleus moves up the fiber attached to it and into one of the cavities. Each of the resulting bodies—the wall of the cavity and the contained cytoplasm and nucleus—is cut off as a spore.

It was long ago suggested that the Fungi are not a natural group; that the Ascomycetes may be placed near the red algae, and the Oomycetes and Zygomycetes broken up and distributed near various groups of green algae. Traces of this arrangement remain in the recent classification of Fungi by Clements and Shear (18). Gäumann (41) accepts most of the Fungi as a natural group derived through Saprolegniales from green algae, but derives some of the chytrids from the rhizopods. Martin (87) maintains that the whole range of Fungi, including Myxomycetes, is a natural group. The evidence seems to me not strongly confirmatory of any of these views. For the present it will be convenient to assume that Martin's view is correct; that Fungi proper and Myxomycetes represent parallel lines of development from more or less the same member of the amoebo-flagellate complex. Under this assumption, natural classification would permit the treatment of Myxomycetes either as a group of Fungi or as a separate group. The more convenient alternative is the treatment of Myxomycetes as a separate group, or their assignment to Rhizopoda, since this facilitates the descriptive definition of the group to which the name Fungi is applied.

PROTISTA: IX. INFUSORIA

Infusoria are distinguished by the possession of cilia, structures typically shorter in proportion to the size of the body than flagella, more numerous, and distributed generally over the surface. The Infusoria reach fairly large sizes, and may be individually visible to the naked eye; they are common, numerous in species, and familiar, and are notable for an elaboration of the structure of the individual cell exceeding that of other organisms. A mouth and gullet (more technically cytostome and cytopharynx) are adaptations for holozoic nutrition. The bases of the cilia are linked together by an elaborate neuromotor apparatus; this does not, however, come into contact with the nuclei. In most Infusoria there are two kinds of nuclei, both represented in every cell; in other words, each cell contains at least two nuclei which are not alike.

Nuclei of the more conspicuous kind, called macronuclei, divide by a non-mitotic process; and, at intervals, they dissolve and disappear, to be replaced by new ones originating by the division of micronuclei. This process is called endomixis. There is a sexual process in which pairs of cells form a junction without losing their individuality. The macronuclei dis-

solve, while the micronuclei undergo three or four divisions including a reduction process (since reduction takes place just before sexual fusion, all nuclei except those capable of fusion are diploid). Each cell receives one of the nuclei formed by reduction division in the other; this unites with one of those formed by reduction division in its own body; the remaining haploid nuclei degenerate and disappear. The cells separate, and in each of them the fusion nucleus divides once or more than once; macronuclei and micronuclei arise by the differentiation of the nuclei formed by these divisions. It is evident that only micronuclei retain the genetic powers of proper nuclei.

It has long been known that micronuclei divide mitotically, and that their membranes do not disappear but undergo constriction at the end of the process. Turner (117), working on *Euplotes Patella*, discovered in the micronucleus an endosome which divides during mitosis, the parts remaining connected for some time by a fiber. The daughter endosomes seem to accompany, rather than to lead, the separating chromosomes; they may be comparable with the endosomes of *Euglena* rather than with centrosomes.

The Infusoria are evidently a natural group. Like red algae, they are a highly evolved group of unknown origin, and an evolutionary blind alley which has led to nothing higher.

PROTISTA: DISCUSSION

A great number of nucleate organisms have now been surveyed under the assumption that they constitute a kingdom Protista. They have been arranged in nine groups which may be construed as phyla or divisions. Some of these are manifestly artificial, but I have tried to show that the whole assemblage is a natural group, that all of these organisms are derived from the one original nucleate organism by lines of descent which lie entirely within the divisions considered (see Fig. 8). If the whole assemblage is a natural group, the question of recognizing it as a taxonomic group, a kingdom, is one of convenience.

One element of convenience, as already mentioned, lies in the feasibility of definition by description. As the Protista are separated from Monera by a broad evolutionary gap, it is easy to distinguish them from Monera by a character, namely, the presence of nuclei. From plants and animals, Protista can to some extent be distinguished by primitive features of the nucleus. The apparently most primitive of known nuclei have a membrane which does not disappear during mitosis, but divides by constriction. Centrosomes, and spindles formed within the intact nuclear membrane, are features of very primitive, if not of the most primitive nuclei. We may regard the permanent nuclear membrane, the centrosome, and the intranuclear spindle, as the positive characters of typical Protista. All these characters fade out in the evolution of various lines: we find the nuclear membrane disappearing at earlier and earlier stages in brown algae and in Fungi; the centrosome, permanent in the lowest brown algae, is present only during mitosis in the higher brown algae; is absent during the second division of the reduction process in *Polysiphonia;* has not been detected in many Basidiomycetes. The spindle originates in the cytoplasm of the sporozoan *Monocystis*. And, while the characters of typical Protista are absent from the higher Protista, they are to some extent present, as would be expected, in the lowest plants and animals.

The kingdoms of plants and animals, being derived groups, are distinguished respectively by combinations of positive characters pecular to themselves. The Protista may be distinguished by the absence of these characters, but it is to be remembered that organisms can be retained as plants or animals even if by degenera-

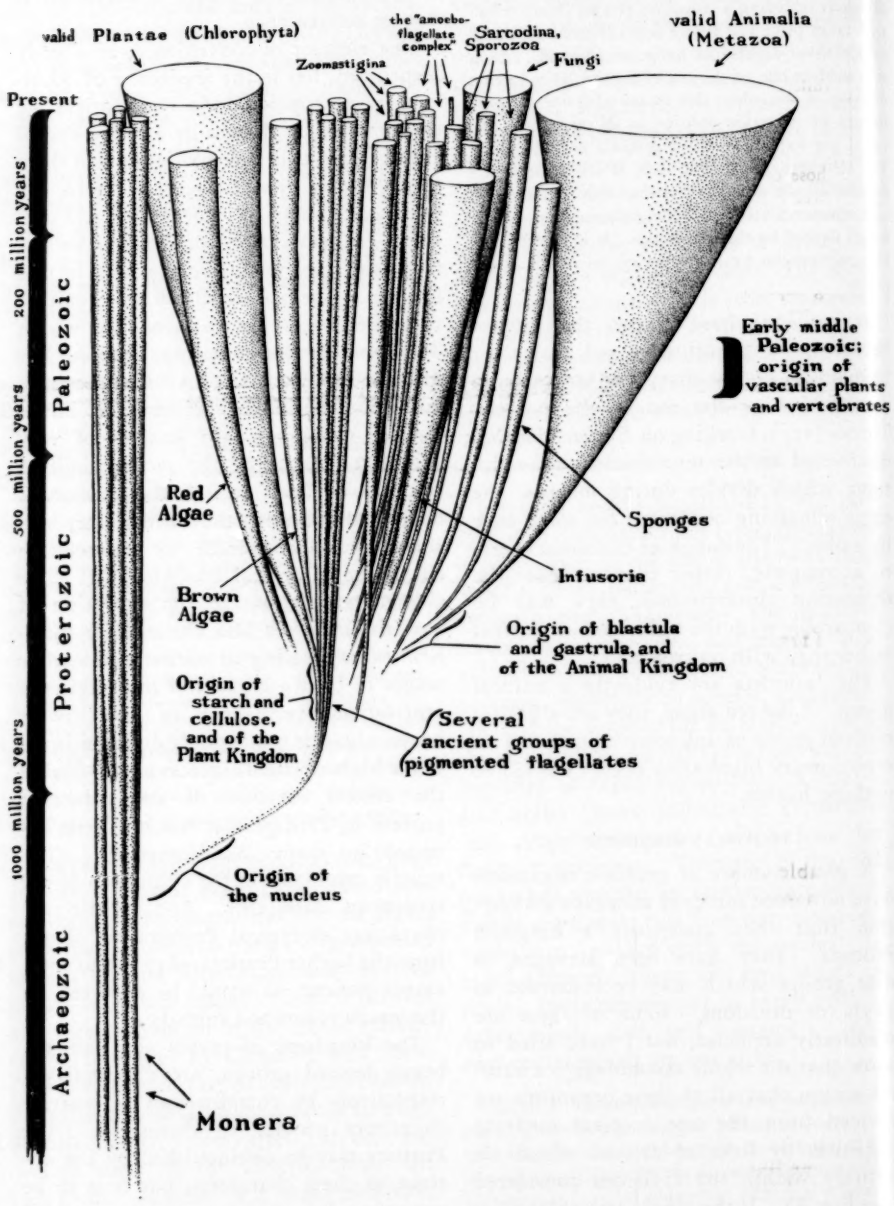

FIG. 8. DIAGRAM OF THE GENERAL PHYLOGENY OF ORGANISMS AS PRESENTED IN THE PRESENT PAPER

tion they lose the characters of the kingdoms to which they belong. Ultimately, it is not by characters but by relationship that groups are defined, and the more extensive the group, the more numerous will be the exceptions to the formal descriptive characters.

We may with equanimity abandon the attempt to define Protista by characters, positive or negative, which will not admit of exceptions. The convenience of the group will appear most definitely by contrast with alternative dispositions of the included organisms.

The traditional disposition of these organisms has been by partition (apparently with a subconscious attempt at equity) between plants and animals. The plant kingdom resulting from this partition, as presented in the text books, includes a group Algae, divided into classes distinguished by pigmentation, as blue-green, green, brown, or red, and a group Fungi, including bacteria and Myxomycetes. It is obvious that by this treatment neither Algae nor Fungi nor the plant kingdom is a natural group. Toward the end of the nineteenth century, Engler and Prantl (38) attempted to correct this situation by annexing the whole group of flagellates. Not all botanists welcomed this proposal; Thaxter (114), an outstanding authority on Myxobacteria, Zygomycetes, and Laboulbeniales (organisms having little enough in common with proper plants) characterized the annexed group as "a menagerie of organisms whose zoology is orthodox to a degree." The real objection in natural classification to the Englerian system is not the orthodox zoology of the flagellates, but the appearance that annexations were not carried far enough. In order to link the Fungi and Myxomycetes into the plant kingdom, we need also the Rhizopoda, and as the annexation of this group leaves the Infusoria and Sporozoa at loose ends in the animal kingdom, we might as well take these groups with the others. This is, indeed, not the only way of setting up a natural system of two kingdoms: the zoologists can keep the Protozoa in their kingdom, if they are willing to accept along with them the Monera, the diatoms, the marine algae, and the Fungi. These groups move as a block; an equitable partition which is at the same time natural is, to present knowledge, an impossibility.

Recognizing the extreme inconvenience of throwing the whole range of Protista (and the Monera along with them) into either Plantae or Animalia, and recognizing also the impossibility of distributing these organisms between the two kingdoms, some authors have proposed to recognize, in place of the one kingdom Protista here described, a series of several kingdoms. This is, for example, the position of Smith (106), who, having distinguished six phyla of algae, remarked that "in reality, the six divisions listed above represent six kingdoms. Five of these kingdoms would have but one division each." Similarly, such a treatment might be satisfactory to Martin (87), who remarked that "Myxomycetes, Phycomycetes, Ascomycetes, and Basidiomycetes . . . together constitute a phylum, to be included among plants as a matter of convenience, but in reality neither plants nor animals, but an independent group of organisms, one of several such." This multiplication of kingdoms is not in itself inconsistent with natural classification, but neither now nor in immediate prospect would it be found practical, in such a multiplication of kingdoms, to make them all natural. A system granting regnal rank to such petty groups as cryptomonads, and to such artificialities as Zoomastigina and Sporozoa, is scarcely desirable. Natural classification permits

all these groups to be treated as one unit, and it is more convenient to do so than to treat them as a dozen or more units.

The balance of authority has been strongly against the recognition of a kingdom Protista. The objection advanced with most show of reason states that the line between plants and animals is recognized with difficulty, and that the establishment of a group placed between them will increase the difficulty by requiring the recognition of two vague lines instead of one. Here I may introduce an analogy. It seems that mankind, for the most part, consists of three races. Imagine that by immemorial tradition mankind has been held to consist of two races: the line between them will be a constant source of difficulty, but the difficulty will become inconsiderable whenever science is persuaded to recognize two lines instead of one. It will presently be shown, of the kingdoms left as plants and animals by the exclusion of Protista, that each of these groups can be defined by positive characters to which exceptions are reasonably few, and that each kingdom is quite definitely limited by its characters to certain subordinate groups. The situation to which objection is made is imaginary.

In undertaking actually to use Protista as a taxonomic entity, I recognize a difficulty which did not concern the authors who refused to do so. Organisms previously within the jurisdiction of two different nomenclatorial codes are to be placed in a group for which no code has been framed: the result may be nomenclatorial confusion. We need not take this difficulty too seriously. The art of nomenclature rests as much on antiquarian as on biological science. We have seen enough nomenclatorial confusion, in the realms governed by codes, to know that biology, and even taxonomy, can survive it. Meanwhile, I have taken advantage of the escape from codes to apply consistently the practice of Linnaeus in capitalizing all specific epithets which are proper nouns.

PLANTS

Such is the concept of Protista, as it has just been formulated, that an account of the characters and limits of Plantae and Animalia will complete the characterization and limitation of Protista, and will, in fact, complete the limitation of kingdoms which is the object of this paper.

The limits of the plant kingdom are those which will include the two groups Chlorophyceae (green algae) and Embryophya (higher plants). The positive characters are the possession of chloroplasts, that is, of plastids containing the four pigments Chlorophyll A, Chlorophyll B, carotin, and xanthophyll (and no others), and the production of two specific carbohydrates, true starch and true cellulose. Some of these characters appear to some extent among Protista. The plastids of Heterokontae, chloromonads, and euglenids can scarcely be called anything but chloroplasts, though they may differ from those of proper plants in the relative abundance of the different pigments. The carbohydrates starch and cellulose have been reported from various Protista. Blackman's (6) account of the dinoflagellate genus *Pyrocystis* refers to a cellulose which does not give a blue color with zinc chlor-iodide, and to a starch which does not give a blue color with iodine. Maltaux and Massart (86) refer without qualification to starch as occurring in the cryptomonad *Chilomonas*. There are other such reports, and it is not improbable that some of them are correct. But no organisms except proper plants show the complete combination of plant characters.

The lowest group in the plant kingdom

as here construed is the order Volvocales. In an evolutionary sense, this group and its descendants, as distinguished from all other organisms, are plants. The Volvocales have the characters of flagellates, and are by zoologists regularly listed as the order Phytomonadida of class Mastigophora. This disposition of the group is in quite as good accord with natural classification as the botanical treatment which places the Volvocales among green algae: we have here a perfect example of an evolutionary link between two groups. The botanical treatment is followed here as being the more convenient, in emphasizing the positive characters, the chloroplasts, starch, and cellulose, of the Volvocales.

We have in Kater's (59) account of *Chlamydomonas* a thoroughly satisfactory description of the nucleus and mitosis of a primitive and typical example of the Volvocales. With this as a starting point, we can make out the course of the evolution of the nucleus in plants: a matter which is of interest as tending to confirm the interpretation of the evolution of the nucleus already given in connection with Protista.

Chlamydomonas (Fig. 9) has a neuromotor system of two flagella, a blepharoplast, a rhizoplast, and an intranuclear centrosome.

During mitosis, all of these are cast off or dissolved except the centrosome; the nucleolus also dissolves, as in higher plants. The dividing centrosome forms an intradesmose, and a spindle forms within the nuclear membrane with the daughter centrosomes as poles. The nuclear membrane persists until mitosis is nearly complete, but eventually dissolves instead of undergoing constriction. The neuromotor systems of the daughter cells are formed as outgrowths from the centrosomes. The whole process is of great interest as being intermediate between what we observe in flagellates and what we observe in higher plants. As in most flagellates, but not the primitive euglenids, the centrosomes have become division centers and the nucleolus dissolves instead of dividing. There has possibly been a stage resembling what we find in the trichomonad flagellates, in which the neuromotor system and nuclear membrane are permanent, being divided and inherited at each division. The dissolution of these parts seems to be a matter of degeneracy of the neuromotor system, but it is a preliminary to advance in the evolution of the organism as a whole.

The Volvocales, with several other orders, belong to the class Isokontae. This is the most significant of the classes of green algae, as being the most numerous in species, and as including both the most primitive green algae and those which come closest to the higher plants. No other Isokontae seem to be as well understood, cytologically, as *Chlamydomonas*. From several genera (see Allen (1) on *Coleochaete;* Timberlake (116) on *Hydrodictyon;* von Cholnocky (17) on *Ulothrix*) there have been reports of granules at the poles of the mitotic spindle; these may be recognized as centrosomes. They are found most usually during the divisions preceding the formation of flagellum-bearing swimming cells.

Among green algae belonging to minor groups—classes apparently derived from Isokontae and leading to nothing further—the genus *Spirogyra* has been the most studied. There is a recent precise account of the behavior of the nuclear membrane and spindle during division by McAllister (88).

The spindle appears first in polar positions outside the nuclear membrane; subsequently it extends within, not breaking through the membrane in any crudely mechanical fashion, but being extended beyond it. The part first formed, outside the membrane, becomes invisible while the part inside persists and functions. The nucleus becomes football-shaped; the membrane remains intact for some time, but eventually, as in *Chalmydomonas*, it disappears, and new membranes are formed about the daughter nuclei. No trace of centrosomes remains; this is perhaps associated with the complete absence of flagellum-bearing cells in the group represented by *Spirogyra*.

It is possible for an organism to retain the occasional habit of producing flagellum-bearing cells after losing all trace of centrosomes, though this situation is not usual. It is exemplified by *Oedogonium*, which represents another evolutionary side-line among green algae. In this genus, Ohashi (92) finds that there is no centrosome. The nuclear membrane disappears early in the mitotic process. When a cell is to develop flagella, a number of granules appear *de novo* in the cytoplasm. They move to the cell membrane and arrange themselves in a ring where the flagella are to form.

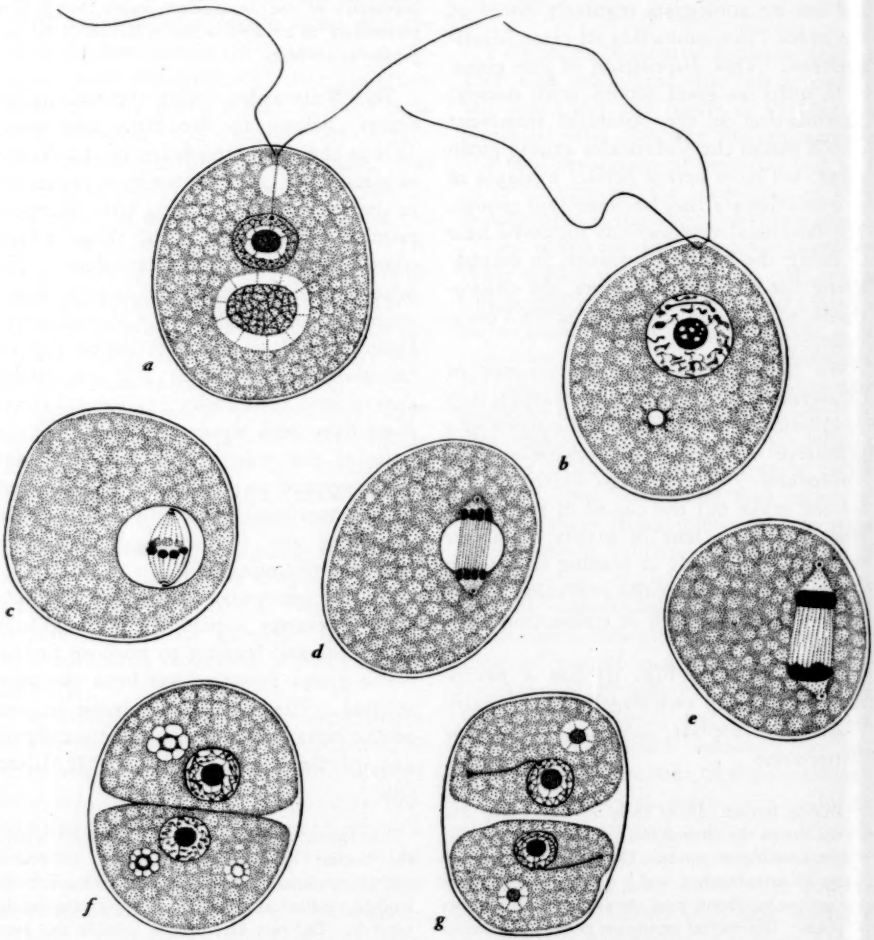

FIG. 9. NUCLEAR AND CELL DIVISION IN CHLAMYDOMONAS NASUTA, AFTER KATER, × 2567

As we turn from green algae to higher plants, we find that many of the latter produce male gametes which are motile

by means of flagella. In liverworts, mosses, and some of the fern allies, the sperms are biflagellate, apparently as an inheritance from the Isokontae; in ferns, cycads, and the maidenhair tree, they bear many flagella, apparently as a modification of the biflagellate condition. The flagella born by sperms of these higher plants arise always from granules which stand at the poles of the spindle during the mitoses by which the sperm nuclei are formed.

There is a considerable literature (cf. Sharp (105)) concerning these granules; they may be absent during all mitoses except those by which the sperm nuclei are formed, or may appear during a few previous mitoses; or, in liverworts, there may be traces of them elsewhere in the body (see Chamberlain (15) on *Pellia* and Van Hook (118) on *Marchantia*). Following Chamberlain (14) and Sharp, we may accept these bodies as being centrosomes, though not all authorities have done so. The additional term blepharoplast, coined by Webber (122), has been found useful in dealing with organisms whose neuromotor apparatus includes a flagellum-bearing structure distinct from the centrosome.

In the highest plants, the conifers and the angiosperms, there are no flagellate cells whatever. There are no traces of centrosomes; nuclear membranes disappear at the beginning of mitosis; spindles originate in the cytoplasm. These nuclear features typical of plants, then, are fully developed only in the highest plants, and are the outcome of a long evolutionary process.

ANIMALS

The only known organisms not accounted for in the foregoing treatment of Monera, Protista, and Plantae, are those which the zoologists call Metazoa. To these, by the present treatment, the kingdom Animalia is limited. All are multicellular, holozoic in nutrition (with exceptions), and (again with exceptions) diploid as to all cells except the gametes. The bodies include freely wandering amoeboid cells. The sperms bear flagella. These characters indicate an amoebo-flagellate ancestry, like that of the Fungi and the various groups of Rhizopoda (as the amoebo-flagellate complex is not in itself a natural group, there is nothing to indicate that the animals, Fungi, and Rhizopoda are related through any ancestor more recent than flagellates).

Centrosomes are present, outside of the nuclei, in the cells of animals; at each mitosis they divide; the spindle is formed between the daughter centrosomes, and enters in among the chromosomes only as the nuclear membrane dissolves.

There are also embryological characters which bind together the great majority of the species. The developing individual passes through a stage in which it is a closed hollow sphere of a single layer of cells, a blastula. The blastula, by one series of stages or another, develops into a more or less spherical body whose wall is a double layer of cells pierced by an opening to the interior; this is a gastrula. An adult *Hydra* is a slightly modified gastrula; a man or a beetle is, in individual development and in evolution, a profoundly modified gastrula. So far as these characters extend, there is a pervading uniformity to animals, marking the group as obviously natural.

Doubt must be acknowledged as to the position of one group. Porifera (sponges) are the most primitive of the groups regularly included in Metazoa. This is the one phylum of organisms whose assignment to a kingdom is made here without confidence. The sponges are clearly descended from the amoebo-flagellate complex, and are in many ways intermediate between the amoebo-flagellate complex and typical animals. It is, however, not certain that they can be construed as exhibiting the embryological

characters of typical animals, and if not, it is possible that their evolutionary origin may have been independent of that of typical animals. If this possibility is the truth, the sponges should be placed among Protista, as in Haeckel's original account of that kingdom, but one tends to assume that they represent a stage in the evolution of typical animals, and are legitimate members of the animal kingdom.

CONCLUSIONS

The evidence and argument presented have been to the effect that organisms can be arranged, naturally and more conveniently than in the past, in four kingdoms, as follows:

1. Monera (Haeckel). Organisms without nuclei, the cells solitary or physiological independent. Groups included, bacteria and blue-green algae. Ancestral form, the original form of life; it is believed to be most nearly represented among living organisms by the nitrifying bacteria. Nomenclatorial type, *Bacillus subtilis*.

2. Protista, Haeckel. Organisms, largely unicellular, with nuclei; typically with permanent nuclear membranes, centrosomes, and intranuclear spindles, though all of these may be lost in evolution; lacking the combinations of characters to be listed as characteristic of plants and animals. Groups included, Flagellata (construed as excluding Volvocales), Rhizopoda, Sporozoa, Infusoria, diatoms, red algae, brown algae, and Fungi. Ancestral form, the first nucleate organism; this is presumably most nearly represented among living forms by the Chrysomonadida. Nomenclatorial type, *Amoeba Proteus*.

3. Plantae, Linnaeus. Organisms (with few and derivative exceptions) having plastids containing the four pigments chlorophyll A, chlorophyll B, carotin, and xanthophyll, and producing true starch and cellulose. The primitive members are motile, unicellular, and have nuclei much as in Protista; the higher are non-motile and of elaborate structure and have no centrosomes nor intranuclear spindles. Groups included, Chlorophyceae and Embryophyta. Ancestral group, Volvocales.

4. Animalia, Linnaeus. Organisms which are multicellular, typically diploid and holozoic, passing through blastula and gastrula stages in development. Centrosomes are present; spindles are generally formed outside the nuclear membrane, and enter the nucleus only as the membrane dissolves. Groups included, the Metazoa as usually construed (except possibly Porifera, which might fall into Protista). Ancestral group, Porifera; or, if that be excluded, Coelenterata.

ACKNOWLEDGEMENTS

Acknowledgements of more than one kind may be in order. The standard taxonomic revision is the work of an expert in the group concerned; it cites all pertinent literature; it is received with respectful interest (never with complete acquiescence) by the author's fellow experts in the same group, and is more or less annoying to others who have to take it into account, as requiring revision of familiar ideas of the limits of groups and the application of names. The present paper, on the contrary, issues from no expert; there lives now no Aristotle or Linnaeus, no one who is an expert on the whole range of life. Accordingly, it may perhaps be an annoyance to all who take cognizance of it. But one who thinks as a taxonomist is unable to withhold his hand from what appears to be an opportunity to make the taxonomic system more natural.

Associated with the fact that this is not the work of an expert is the fact that the bibliography is fragmentary. The literature pertinent to the present subject is a major fraction of the whole literature of life. I have studied what literature was readily at hand; I have leaned heavily on the advanced textbooks (5, 9, 11, 18, 36, 57, 81, 84, 85, 90, 97, 103, 105, 106, 123, 125); the original contributions consulted have been largely recent and largely American. I regret having overlooked many pertinent contributions, which it would have been only just to have

cited, but I believe that the evidence assembled is typical of the whole body and makes a strong case.

No part of the data presented is my own discovery. Of the ideas, I can claim as my own only the delimitation of the kingdom Protista. The remaining ideas are assembled from many sources—from reading, from conversation, from instruction. My teacher, in principles of classification, has been my father, Dr. E. B. Copeland; in cytology, Dr. C. E. Allen; in the science of algae, Dr. G. M. Smith. I am keenly aware of my indebtedness to them, and again to my father, and to my colleagues, Dr. H. J. Child and Dr. H. C. Day, for interest during the preparation of this paper and for searching criticism of fact, of inference, and of presentation. But no responsibility for the outcome is to be attributed to any of these gentlemen.

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BIOLOGICAL EFFECTS OF POPULATION DENSITY IN LOWER ORGANISMS

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INTRODUCTION

PEARL (1937) defines a population as "a group of living individuals set in a frame that is limited and defined in respect of both time and space." The science of group biology, he points out, "aims to describe the attributes and behavior of a group as such, that is as an entity in itself, and not as the simple sum of the separate attributes of the single individual organisms that together make up the group." The three principal group characteristics are size, growth, and quality. The latter refers to the genetic constitution of the population and its phenotypical representation. It is obvious that the genetic constitution is an important factor influencing the reproduction rate which in turn determines the primary group characteristic of "size" at any particular instant of time. Chapman (1928) has attempted to make a mathematical generalization of the interaction of these three factors in any population, borrowing his terms from Ohm's law of electrical conduction which is usually expressed as $\left(\frac{E}{B} = I\right.$ where $E =$ the potential, $R =$ the resistance, and $I =$ the current). He calls the major component of importance for population physiology in Pearl's qualitative factor the "biotic potential," corresponding to E of Ohm's law, defined as the "mean maximum rate of reproduction in given period under given conditions."

Every species of plant and animal has its own inherent "biotic potential" as every electric battery has a particular electric potential independent of the environment. The death rate, shortening of life span and fertile period, and the lowering of fertility and fecundity, etc. is called the "resistance" (R) which the environment puts up to the "biotic potential." The interaction of these two factors determines the value of I, the net rate of growth of the population. I in time, of course, determines the population density which, as will be shown later, is an extremely important component of R, the environmental resistance. Therefore, I is the instantaneous rate of growth determined by its own previous values and the time through which they have been acting. It should be noted here that this "Ohm's law for biology" must not be examined too closely, and though the idea is admirable Chapman is probably a little too optimistic about its applied value.

In 1838 Verhulst (1838) discovered that the S-shaped curve, which he called the "logistic curve," was a good fit for the growth of human populations. The first derivative of this curve gives the rate of growth in respect to time or in respect to size of population. This curve was later independently rediscovered as a population curve by Pearl and Reed (1920) who found it to be an excellent description of the growth of a great variety of animal

and plant populations, as well as of human populations; in short, that it expressed a general law of population growth, probably for fundamental biological reasons. Reed and Berkson (1929) have described the characteristics of the logistic curve for various values of the constants and explained the most satisfactory methods of fitting it. Pearl (1925, 1927, etc.) has shown that the logistic as well as expressing population growth in man, *Drosophila*, bacteria, yeast, etc., also may describe the growth of an individual (rat, tadpole, pumpkin, etc.).

An analysis of the logistic curve itself throws considerable light on the group attributes of populations at various stages of growth. Miner (1932), for example, showed that the birth rate in a logistic population can be expressed as a function of the population density and that this functional relationship is the same as that between the mean free path of the molecules of a gas and its density. This conclusion would seem at least to hint that the effect of crowding on the birth rate is a direct effect of interference between the individuals rather than an indirect nutritional effect as was generally believed. It will be shown later that experimental work seems to substantiate this idea in a few particular cases. But Pearl and other workers soon became interested in determining the biological nature of the various factors lying back of the production of the growth curve and set up experiments to analyze them bit by bit. Recently, Pearl (1938) has done valuable work in determining fertility factors in man with special reference to age, coitus rate and use of contraception. But due to greater ease of handling and to financial limitations most of the more particular analysis has been accomplished by means of animal experimentation.

At first glance, it would seem to be a virtually hopeless task to make a study of population leading to any broad generalizations due to the great diversity of types of aggregations of living organisms. For example, many believe that the population physiology is fundamentally different in an aggregation of animals held together merely because of limitations of space or because of mutual attraction for the same environment (moths about a flame) and a "society" held together by "social instinct" apparently for the "purpose" of mutual benefit. Alverdes (1927) bases his classification of animal aggregations on this distinction. Yet, non-social animals, man, and individuals which may be considered as a highly organized population of cells all follow the same growth curve. Bodenheimer (1936) has recently shown that highly organized colonies of termites, ants, social wasps, bumble-bees, and social bees all grow logistically and states that "the growth of these colonies resembles that of organisms." Mainly because the social or semi-social animals are very difficult to work with experimentally, in almost all of the experimental work about to be described the population density has been controlled merely by the size of the environment (rather than by crowding conditioned by the instincts of the animals themselves). Therefore, highly developed social activity does not enter as a complicating factor although the behavior reaction of the animals toward one another at various densities undoubtedly does play a part. Because of the similarity of end result previously mentioned, there is reason to believe that much of what has been discovered by the study of such relatively simple types of animal grouping also applies to organized societies, though with certain modifications.

POPULATIONS OF MICROORGANISMS

1. Rhythms and cycles in fission rate

The effect of crowding on the growth rate of a population was probably first studied experimentally by Woodruff (1911) working with *Paramecium aurelia* and *P. caudatum*. He placed these animals in from 2 to 40 drops of hay infusion, changing them to new medium every day, or in some cases every other day, and followed the growth cultures for from 16 to 20 days. He found that for both species the greater the volume of culture medium used the more rapid was their rate of reproduction. Likewise, in the 2-drop cultures the division rate was greater when they were changed to new medium every day than when they were only changed every other day. When he used culture medium in which *Paramecia* had been growing for a number of days and then strained off the organisms, other *Paramecia* placed in it did not have as high a division rate as they had when placed in a fresh medium. From these facts he concluded that *Paramecia* excrete substances toxic to themselves and that these substances are more effective when the organisms are confined to a limited volume of culture medium. Therefore, he reasoned, excretory products play an important rôle in determining the period of maximum numbers, the growth rate, and the rate of decline of populations of these animals.

These results were so clear cut and so reasonable that they were not questioned for a number of years while interest centered about the question of the necessity of conjugation and encystment and their place in the life cycle. It was generally agreed at the time that populations of infusoria go through "life cycles" from the "birth" of a new culture with a period of growth followed by a period of decline, old age, and finally death unless the race is "rejuvenated" by conjugation, encystment, or a change of environment. Within the cycles Woodruff (1905) also reported minor fluctuations which he called "rhythms." He defined a rhythm as "a minor periodic rise and fall of the fission-rate, due to some unknown factor in cell metabolism, from which recovery is autonomous." Both "rhythms" and cycles were demonstrated in *Oxytricha fallax*, *Pleurotricha lanceolata*, and *Gastrostyla steinii*. Gregory (1909) reported that the ciliate *Tillina magna* "shows the normal rhythmic fluctuations observed by Woodruff" and other workers found the same to be true of various other protozoa. Pearl (1907) reported a particularly interesting biometrical study on the effects of conjugation on *Paramecium caudatum*. By measuring a large number of conjugating and non-conjugating pairs in the unfavorable environmental conditions which lead to conjugation, he found that *Paramecia* alike in respect to length tended to pair, and that conjugation appeared to restrict variation and lead to stability of type rather than the reverse. This is interesting in light of recent assertions, based on theoretical considerations, that the value of sexual reproduction and therefore its evolutionary development was due to its leading to a greater number of variations for natural selection to operate upon. Moody (1912) reported that *Spathidium*, an organism which depends upon *Colpidium* for its food supply encysts if its numbers increase to a point where it reduces the *Colpidium* population to the vanishing point.

In 1911 Woodruff and Baitsell discovered that they could breed *Paramecium caudatum* indefinitely without conjugation by the use of a good culture medium (beef extract) or by varying the culture medium, but

that the rhythms persisted. By 1914 Woodruff and Erdmann were willing to say that "the so-called life cycle is non-existent." They accounted for the rhythms as resulting from an internal phenomenon, which they called "endomixis," during which a complete new nucleus of micronuclear origin is formed. Erdmann and Woodruff (1916) showed endomixis for the three races of *P. aurelia*. Woodruff (1925) expresses the opinion that the rejuvenation common to both conjugation and endomixis is due to intercellular changes apart from genetic factors. He has now, Woodruff (1926), bred *P. aurelia* for 11,000 generations without conjugation but with endomixis and resultant rhythms in fission rate occurring at intervals.

It is by no means certain that endomixis is any more essential to the continuation of life than is conjugation. Patten (1921) bred for eight months or 652 generations a pedigreed line of *Didinium nasutum* all progeny of the same conjugant which had no micronucleus. Rhythmical periods of depression followed by increased vitality occurred resembling those generally associated with endomixis; but endomixis never occurred, no micronucleus ever appearing in these animals in any period. Those animals which encysted or conjugated invariably died, "a fact undoubtedly related to their amicronucleate condition." As far back as 1917 Mast reported that he was able to raise *D. nasutum* without finding any cycles in their death rate or reproductive rate and found no evidence that either encystment or conjugation is a rejuvenating process. Beers (1928) reports that he raised *D. nasutum* under "practically" constant conditions for 265 days (925.5 generations) without the appearance of endomixis or any rhythms in the fission rate such as Woodruff describes. However, he was able to induce rhythms easily by slight variations in the food and thinks that this may account for the phenomena observed by Woodruff. It may be, then, that Pearl's discovery that conjugation preserves the stability of the species is the key to the real value of the nuclear reorganizations rather than a "rejuvenating" process. If a "run down" culture tends to produce variations, a return to the old type of organization of proven survival value might well appear to be "rejuvenation" as in the great majority of cases the conservative type would be better than new random variations, once good environmental conditions were restored.

In any case, conjugation, encystment, and endomixis are extremely important factors in the normal population physiology of these organisms. Barker and Taylor (1931) have shown that encystment is ordinarily dependent upon a high population density in *Colpoda cucullus*. When these animals are not numerous the encystment is dependent "upon a cumulative alteration of the medium brought about by the animals themselves." The greater the population density the sooner encystment occurs while the pH of the medium and the food concentration have little effect. Though the other authors do not directly state it, their experiments with *Paramecium* and other infusoria seem to indicate that overcrowding is one of the most common factors which leads to unfavorable environmental conditions and consequent conjugation.

2. *Allelocatalysis*

There was no questioning of Woodruff's (1911) evidence that crowding was unqualifiedly detrimental to infusoria and little or no further interest was taken in the matter until 1921 when Robertson published a series of papers in which he sought to prove that just the opposite was

true. He first found (Robertson, 1921a) that while a temperature of 30°C. kills isolated individuals of the small infusorian *Enchelys parcimen*, a culture initially containing a large number of them will survive and continue to multiply even at considerably higher temperatures. In other words, the group has a protective value for its individual members. Then he found that if he let a hay infusion become bacterized by standing for from 24 to 72 hours, the infusoria placed in it had a much higher rate of division than in a newly made infusion and that the period of declining fission rate was put off considerably. From this, he postulated that the bacteria liberate an "X-substance" autocatalytic for reproduction. Shortly after this, Robertson (1921b) found that if he isolated two individual infusoria in one drop of culture medium the division rate during the first 24 hours was higher than it was if he isolated just one individual per drop. From this he reasoned that the infusoria themselves liberated a substance identical to the "X-substance" he claims was produced by the bacteria. The effect was not due to the infusoria inoculating the culture with bacteria since it occurred in bacterized medium as well as in a medium filtered free of bacteria.

In a series of papers which followed, Robertson (1922, 1924a, 1924b, 1924c, 1927) expanded and refined his explanation of this phenomenon which he called the "allelocatalytic effect" or "allelocatalysis." On the factual side, he stated that "an old culture-fluid contains no substances which are toxic for infusoria, nor does it retard the multiplication of infusoria isolated into it from young cultures"; old culture medium, on the other hand, contains a substance "which enhances the multiplication rate of isolated infusoria"; the smaller is the volume in which a single infusorium is isolated, the greater is the initial reproduction rate of the culture, etc. He found that the reproduction rate may be sixteen times as great when two animals are isolated in a single drop of medium as when one animal is so isolated. By way of explanation, Robertson (1922) said: "The accelerative agent in cellular multiplication originates in the nucleus, and the autocatalytic time-relations which distinguish all types of growth are referable to the fact that nuclear synthesis is autocatalyzed." The "X-substance" is a portion of this nuclear catalyst liberated into the surrounding medium at the time of cell division.

These papers immediately attracted a great amount of interest on the part of a considerable number of workers. For some time no one was able to reproduce Robertson's results and the fact of "allelocatalysis" was disputed, not to say the explanation.

Cutler and Crump (1923a and 1923b) were unable to find any evidence of allelocatalysis in *Colpidium colpoda* and concluded that it did not exist for this animal at least. Robertson (1924b) replied that he could obtain it with *Colpidium* using Cutler and Crump's medium and claimed that they did not find it due to faulty technique in not washing their animals and so transferring some of the old medium with its "X-substance" to the new medium. Cutler and Crump (1924) added to their previous work showing that the number of divisions of *Colpidium* in a given time was "intimately associated with the size of the bacterial population" and that the number of divisions steadily decreases as the number of animals inoculated in a given volume increases.

Greenleaf (1924 and 1926) conducted a long and well-controlled series of experiments on *Paramecium aurelia*, *P. caudatum*, *Pleurotricha lanceolata*, and *Stylonychia pus-*

tulata, rearing various numbers of animals in 2, 5, 20, and 40 drops of hay infusion both fresh and old. His results entirely backed up Woodruff's (1911) original assertion that the metabolic waste products are harmful to the animals. No allelocatalytic effect was observed in any series. The division rate of a single animal was greater than that of two animals originally placed in the same volume of fluid.

Peskett (1925) found no allelocatalytic effect in the growth of yeast. Myers (1927) met Robertson's objection to the work of Cutler and Crump by washing his animals before placing them in fresh medium, but still found no allelocatalytic effect. Darby (1930) working with yeast and *Paramecium* and Phelps (1935) working with the ciliate *Glaucoma pyriformis* in bacteria-free culture media likewise could find no such effect as reported by Robertson.

On the other hand, Yocom (1928) raising *Oxytricha* on a sterile medium of .05 of one per cent of beef extract found an allelocatalytic effect and thought that Robertson's explanation was more satisfactory than any other. In his experiments, he placed 4 drops of medium in one depression and 10 drops in another depression of a glass slide, isolated one animal in each depression, and counted the number of animals at the end of 24 hours. At 28°C. the 4-drop cultures had on the average 10.2 individuals as compared with 9.08 individuals in the 10-drop cultures. At 23°C. the number of individuals in 24 hours was 9.07 compared with 8.10 and 3.54 compared with 2.91 for the 4-drop and 10-drop cultures respectively.

Peterson (1929) working with *Paramecium caudatum* found no difference in reproduction rate in 2 and 4 drops of medium between 1 and 2 animal cultures whether the animals were washed or unwashed and found that one animal isolated in "conditioned" medium had a greater division rate in a large volume than in a small volume. But unwashed animals placed in sterile medium had a higher division rate in a small volume than in a larger volume. When 1, 2, 4, or 8 unwashed animals were placed in 1, 2, or 5 drops of bacterized medium, the greatest reproduction rate occurred in 5 drops of medium originally containing one animal. But when either washed or unwashed animals were placed 1, 2, or 4 at a time in 20 drops of bacterized medium the highest division rate occurred in the 4-animal cultures and the lowest occurred in the 1-animal cultures. He thus demonstrated an allelocatalytic effect under certain conditions but at the same time showed that it depended upon a more complex balance of volume, food supply, and number of animals than Robertson had imagined.

Luck, Sheets, and Thomas (1931) showed the great importance of the food supply, particularly bacteria, in the division rate of *Euplotes*. Loefer (1936) showed the importance of salts as well as organic materials in the growth of *Paramecium bursaria*. Smith (1932) working with *P. caudatum* beautifully demonstrated the importance of an optimal food concentration. He showed that a particular optimum food concentration gave a far higher reproductive rate than any greater or lesser concentration and came to the conclusion that at the beginning of a new culture this plays a greater rôle than the number of animals present. Johnson (1933) found the same to be true for *Oxytricha*, the food concentration being determined by the number of bacteria present. At certain concentrations of food he found that single animal cultures had higher reproductive rates if started in smaller volumes than if started in large

volumes and that in the same volume 2-animal cultures had a higher fission rate than 1-animal cultures eq. (allelocatalytic effect). Johnson (1936) elaborated on these experiments, this time using *Paramecium caudatum* and varying both the bacterial concentration and the number of animals at the start and observed the cultures for a seven-day period. A certain "x-concentration" of bacteria gave the highest rate of reproduction in both 1- and 5-animal cultures on the first day; while after the first day, 5-animal cultures and after the second day, 1-animal cultures had a higher division rate in 5 x concentration than in x concentration of bacteria. After the first day, 1-animal cultures had a higher division rate than 5-animal cultures in x concentration of bacteria. During the second day 5-animal cultures had higher division rates than 1-animal cultures in 5 x concentrations but after the third day the 1-animal cultures had the higher division rate.

These latter experiments all indicated that the reproductive rate of infusoria is in some way controlled by the interaction of numbers, concentration of food, and volume of the medium rather than by any of them alone. The experiments of McPherson, Smith, and Banta (1932) throw a great deal of light on this. They found that when a strong culture medium (one with a high food concentration) was used the allelocatalytic effect was observed but when they used a weak culture medium the reverse occurred. These results were obtained both with *P. caudatum* and with parthenogenetically reproducing females of the water flea *Moina macrocopa*. This suggests as the most likely explanation of all the phenomena observed that the effect of numbers on reproduction rate depends upon whether the presence of the animals themselves is shifting the environmental conditions nearer to or farther from the optimal point. Thus, if there is too great a concentration of food a larger number of animals might be expected to lower the concentration and thus create better conditions for themselves. On the other hand, if there is not enough food, the reduction of the available supply by the animals would make matters still worse for them, and so lower the reproductive rate. Such an explanation seems more rational that bringing in an "X-substance" which no one has been able to isolate or otherwise directly demonstrate. However, the protective value of the group against high temperatures is yet to be explained. Jahn (1934) and Johnson (1937) have reviewed the literature and theories dealing with this phenomenon. The latter agrees in general with the type of explanation just given and the former points out that besides changing the food supply the animals themselves might bring the pH, the oxidation-reduction potential, and the CO_2 concentration nearer to the optimal point.

AQUATIC ANIMALS

At about the same time, Drzewina and Bohn in France and Allee and his associates in America found certain remarkable effects of crowding on aquatic animals and started long series of investigations to clear up the matter. Allee (1931 and 1934) has fully described the results of this work, so as it is of less immediate interest to the subject of this paper than literature to be described later, I will only outline it here.

The work of Drzewina and Bohn (1910–1927) and Bohn and Drzewina (1920–1932) all centers about the effect of toxic substances in water in which animals are living. *Convoluta*, a small turbellarian, dies quite quickly if put in fresh water. It was found, however, that a group of these animals can survive when a propor-

tion of fresh water is added to sea water which kills a single animal in the same volume (Bohn and Drzewina, 1920). In other words, the group has a protective effect against this unfavorable environmental condition. Colloidal silver added in small proportions to sea water proved to be very toxic to *Convoluta*, but a group of these animals was able to survive in concentrations which killed single individuals (Drzewina and Bohn, 1921a), which phenomenon was named "auto-protection" by the authors. Groups of tadpoles also protected themselves from the toxic effect of colloidal silver which killed single individuals. Two small tadpoles placed in a small volume of a colloidal silver suspension will live indefinitely, while if placed in a larger volume with the same concentration of silver they soon die (Drzewina and Bohn, 1921b, c, d).

The spermatozoa and eggs of the sea urchin respond in the same way to crowding under unfavorable conditions. Spermatozoa were treated with dilute suspensions of neutral red (Bohn and Drzewina, 1923) and colloidal silver (Drzewina and Bohn, 1920) and with dilute solutions of potassium chloride (Drzewina and Bohn, 1923) and in each case the larger the number of spermatozoa the longer they retained their power to fertilize eggs. Bohn-Drzewina (1926) likewise found that a large group of spermatozoa could withstand high temperatures which are fatal under less crowded conditions. It has always been something of a puzzle why such enormous quantities of spermatozoa are produced in most species when so very few are used. But if a single spermatozoon dies under conditions which a mass of them survive, then the chance for successful fertilization of eggs when large numbers of spermatozoa are produced is far greater than the product of an isolated individual's chance for success times the number of individuals. Thus the great majority of spermatozoa that are doomed to die first perform the useful service of protecting their more successful rivals.

The effect on sea urchin spermatozoa of a concentrated solution of CO_2 is more puzzling (Drzewina and Bohn, 1926c). Spermatazoa in large numbers exposed to a concentrated CO_2 solution for a few moments do not lose their mobility and are able to fertilize eggs, but no fertilization membrane forms and the eggs develop abnormally. Spermatazoa in smaller numbers under the same conditions lose their mobility but recover in about a half an hour and can then fertilize eggs which will develop a fertilization membrane and then develop normally. When left in this solution for from 20 minutes to one hour, a large mass of spermatozoa gradually recovers the ability to fertilize eggs with normal results while a small mass loses more and more the ability to do so.

Colpidium, *Paramecium*, and other infusoria, *Hydra* and several planarians were all found to be protected to a greater or less degree by crowding from the poisonous effects of colloidal silver, various salts, and other substances (Drzewina and Bohn, 1921c, e). One might suppose that the power of the group to protect would be in inverse proportion to the concentration of the poisonous substance (if the protection is due to the animals giving off some antitoxin) but these authors find that the survivorship is dependent to a very much greater degree upon the density of the animal population than upon the concentration of the poison (Drzewina and Bohn, 1921e, and 1923). But crowding does not always have a desirable result for these forms and in fact just the opposite effect; auto-destruction occurs under some conditions (Drzewina

and Bohn, 1922). Potassium chloried added in small quantities to sea water proved to be toxic and tests were made in which (a) 25 *Convoluta* were placed in 2 cc., and (b) 250 *Convoluta* were placed in 2 cc. of such a solution; the concentration of KCl being the same in both cases. In the lower density (a), most of the animals died in one to two minutes but some of them lived. But in the high density, (b), some sticky substance was produced by the animals themselves and in a very short time they were all stuck together and soon died. The authors compare this to the agglutination of bacteria produced by antibody in the blood of a host. Likewise, the small fresh water planarian *Polycelis nigra* was able to survive in a large volume of a dilute KCl solution but died in a small volume of the same solution (Drzewina and Bohn, 1921e). The authors offer the explanation that the worm responds to the KCl by putting out some substance, presumably to counteract its effect, but that this substance is poisonous to them (under these conditions at least) and in small volumes becomes sufficiently concentrated to kill them.

It was also found that the presence of certain insoluble solids would have an effect on animals in liquid medium (Drzewina and Bohn, 1926a, b, d; 1927, a and b; Bohn and Drzewina, 1932). *Convoluta* die quickly if placed in a silver container in the light but survive several hours if in the dark. The same is true if the walls of the glass container are coated with stearine, but tin and paraffin are as harmless as glass. As water which has stood in a silver or stearine container is not toxic, the effect is not due to a soluble poison. The authors suggest that the silver acts as a catalyst for some harmful reaction. Strangely enough, if *Convoluta* are put in a container with both silver and tin sheets, the latter protects them from the former and they live unharmed! Sea urchin sperm lose their power to fertilize eggs very quickly if metallic silver is present, but a large group of them exhibit mass protection and can retain their power to fertilize for over an hour in a silver vessel. Metallic silver does not always have a bad effect however; while it inhibits the growth of the roots of tobacco seedlings, it accelerates the growth of the roots of water cress seedlings (Bohn and Drzewina, 1932).

Allee and Bowen (1932) tested the effect of colloidal silver on gold fish and found that a group of them survive longer than a single individual placed in the same volume and concentration. On the other hand, if various numbers of fish are used but the volume of water and concentration of silver are kept the same *per fish*, the group has no superior protective value over the single individual. In other words, the degree of protection is determined by the volume of gold fish as compared with the amount of silver and if this proportion remains constant the number of individuals does not matter. Carpenter (1930) determined how great a concentration of salts of heavy metals (Copper, zinc, etc.) could be withstood by fresh water fish. Salmonidae are particularly sensitive to extremely dilute metallic ion solutions, such as water which has come in contact with mine workings or passed through metal pipes, and this is a serious practical problem. She worked out the following relationship for the survival time of fish placed in such toxic reagents:

$$K = \frac{1}{t} \log \frac{1}{\text{molar concentration}},$$

where t = survival time and K = a constant for the species of fish. In such solutions, the fish rapidly excrete mucus which tends to fix the metal salts and remove them from solution. Thus in a

limited volume a group of fish is able to protect its component individuals from the poison, the mucus acting as an antitoxin, and the greater the bulk of fish (both as to number and as to size) the greater will be the protection. If the original fresh water fish are removed from a tank of water which contained metal salts and other fish are put in, these newcomers will survive much longer since the first fish removed some of the salts and so *conditioned* the water for them. There are harmful effects of overcrowding however, and in pure water a large group of fish will not live as long as a smaller group. These harmful effects of crowding are so apparent that they have attracted little interest, most workers preferring to study the beneficial effects. Shaw (1932) showed that the presence of mussels has a beneficial effect on the growth of fishes placed in water with sub-lethal doses of $HgCl_2$ and NH_4Cl.

While fresh water animals may remove metallic salts from water and so protect themselves, Allee (1928) has shown that salt water animals may increase the salinity of fresh water in which they are placed. Thus a number of turbellarian worms, *Procerodes* a marine form, may survive in a limited volume of fresh water while a single worm dies. Allee (1933) showed that water from old *Procerodes* cultures protect these animals when they are placed in fresh water.

Stone head catfish, *Schilbeodes melas*, occasionally aggregate under natural conditions. Working with them in the laboratory, Eddy (1926) says that "the rate of carbon dioxide production showed that the rate of respiration was decidedly increased by even the presence of one other individual." The black catfish, *Ameiurus melas*, normally forms bunches and Eddy found that fish just removed from the center of a dense, active aggregation have a higher rate of oxygen consumption than those from small aggregations of two to four individuals while fish which voluntarily isolated themselves from the group had a considerably slower rate of oxygen consumption than either. Fish taken from the center of a dense, active, naturally formed group and isolated for several days still had a higher rate of oxygen consumption than individuals that voluntarily isolated themselves. This latter fact might be interpreted either as meaning that grouping has a lasting effect on metabolism or that the rate of metabolism influences the tendency to form groups.

Allee (1927) says that brittle starfish, *Ophioderma brevispina*, normally aggregate in some shaded spot or about some quiet individual. This tendency seems to be due to mutual attraction to the same environmental conditions rather than to social instinct. The members of such groups usually live longer than isolated individuals, but under certain bad environmental conditions the reverse is true. Crowding was found to lessen at first the oxygen consumption of the individuals but after a period of about six hours to increase it. Allee and Fowler (1932) later found that this response varied seasonally. The first oxygen consumption test had been made in the autumn, outside of the breeding season. A test made during the breeding season under the same conditions showed that when first crowded the starfish consume more oxygen than isolated individuals at this time of the year. Complicating factors rather difficult to understand were discovered when in further tests glass rods were placed in the containers to simulate the eel grass in the natural environment. With these rods present the starfish responded to crowding in the breeding season as they had responded (in

respect to oxygen consumption) outside of the breeding season without glass rods! Much more work will be required to clear up this puzzling matter.

Allee (1925 and 1926) found that land isopods have a strong tendency to bunch under some conditions (a dry substrate being the most common cause) and this bunching lowers the oxygen consumption and carbon dioxide output (per unit weight of isopods) for the first hour or two and then increases it. The fact that the animals remain quiet when first grouped is a partial explanation. Land isopods require a very damp environment and die if there is not enough moisture. As grouping lessens the rate of evaporation, it has a protective value in dry periods which is the time when the groups naturally tend to form.

Adolph (1931) found that crowding tadpoles has little effect on their early growth but that crowded animals stop growing much sooner than isolated individuals. He demonstrated very convincingly that this is not due to any conditioning or poisoning of the water but simply due to the mechanical (or psychological) interference of the animals with each other. The crowding effect was just as marked when fresh water was continually and rapidly run through the container as when it was not changed; while merely partitioning the individuals off from one another without changing the volume of the container eliminated the bad effect of crowding. Simply agitating the individual tadpoles had the same inhibiting effect on growth as crowding. Shaw (1932) on the other hand "conditioned" water by letting animals live in it for a while and found that *Amblystoma* larvae regenerated amputated tails quicker in such water than in fresh water. Filtering conditioned water destroyed this growth stimulating quality. Allee, Bowen, Welty, and Oesting (1934) found that adult fish grow less under crowded conditions than when not crowded, particularly if the water is not changed. But there was some indication of an optimal density of more than two fish per aquaria for the growth of young fish in the first few days and Church (1927) reported the same thing. In general, they found that young fish grow more rapidly in homotypically conditioned water than in fresh water. Straining out the faeces, autoclaving and evaporating and rediluting the conditioned water did not change its effect. These fish lived considerably longer in conditioned distilled water than in freshly distilled water since they lose electrolytes rapidly to the latter. So the beneficial effect of conditioned water, in a few cases where it is found to be beneficial, is to be accounted for partly at least on the basis of a more nearly optimal osmotic pressure. Greenberg and Schmidt (1936), Wulzen (1929) and many others have found that certain food substances such as egg and certain extracts from animal tissues are greatly stimulating to the growth of worms and other aquatic animals. Allee, Oesting, and Hoskins (1936) therefore investigated the possibility that homotypically conditioned water contains food substances which would account for its growth stimulating quality. They found that regurgitated food and the faeces found in gold fish conditioned water were available as food for fish but they nevertheless felt that some other biochemical substance with growth promoting power may be present in conditioned water. Evans (1936), suspecting that conditioned water may be richer in vitamins, tested the growth of gold fish under the following conditions: (a) vitamin-rich diet, homotypically conditioned water, (b) vitamin-rich diet, fresh water, (c) vitamin-free diet, homotypically con-

ditioned water, (d) vitamin-free diet, fresh water. The animals grow best in conditioned water (a) and (c). In conditioned water the presence (a) or absence (c) of vitamins made no difference nor did it make a difference in fresh water (b) and (d). She concluded that vitamins are not the growth promoting factor in conditioned water.

As things now stand, the existence of any growth promoting factor, other than food, in homotypically conditioned water is yet to be definitely proven; and, of course, the nature of any such substance is quite unknown. This whole line of investigation is very similar to the search for Robertson's "X-substance" to explain allelocatalysis in the protozoa. Allee still seems to be quite open-minded on the question.

INSECTS

The previous experiments described were designed to explain a few particular aspects of the population problem in a variety of different animals. Two insect species, however, have proven to be such excellent experimental subjects for the purpose that it has been possible to analyze nearly every phase of their population physiology quantitatively as well as qualitatively. These are the common flour beetle, *Tribolium confusum* Duval, and the fruitfly, *Drosophila melanogaster*. Both are easy to raise under laboratory conditions and go through complete metamorphosis with sharply divided egg, larval, pupal, and imaginal periods. The flour beetle has the advantages that the laboratory culture conditions are almost identical to those of its natural habitat, it can be handled and the numbers counted at every stage of development, and the sexes can be distinguished in the pupal period; disadvantages are that it is relatively long lived with a considerable period from generation to generation, the sexes cannot be distinguished in the adult stage, and the handling is too laborious to permit the use of large numbers. On the other hand, tens of thousands of *Drosophila* can be used in an experiment; they have a relatively short life span, breed very rapidly, the eggs as well as the adults can be counted, and the sexes determined in the adult stage. The major disadvantage with *Drosophila* for population work is that no successful technique has been developed to handle, sex, and count large numbers at intervals during the larval period without running the risk of injuring them.

1. *Tribolium experiments*

Tribolium, according to Good (1933), apparently lived originally and can still be found under the bark of trees and in rotting logs. But almost any powdered food provides it with a good environment and today it is found throughout the world thriving in flour and other ground food. There are two common species, *T. ferrugineum* and *T. confusum*, very similar in appearance and in habits, the former, however, preferring a somewhat warmer climate than the latter. Both species can breed regularly all year around in heated houses, but otherwise they breed only in summer, passing the colder months in the adult stage. As practically all the experimental work has been done with *T. confusum* Duval, the following discussion will be confined to this species.

Park (1934c) has given a fairly detailed description of the general biology and living conditions of this animal. He customarily raises them in unbleached white flour at a constant temperature of 28°C. and at as constant a relative humidity as he can obtain. Under these conditions, the eggs hatch in from 5 to 7 days (average about 6 days), after being laid;

the larval period lasts from 30 to 40 days (average about 37 days); the pupal period from 6 to 8 days; and while the life span of the adults is not accurately known, more than half of them live for over a year and a fair number survive for over two years. The adult females produce eggs soon after emerging, but fertile eggs are seldom laid in less than two weeks time. This makes about nine weeks as the shortest average time from generation to generation, while for the practical problem of carrying through experiments only four to five generations can be conveniently run in a year's time. The beetles and their eggs can be separated from the flour by sifting and Park (1934c) has designed a mechanical sifter to speed up this process. Since the sex of the adults cannot be determined by inspection without killing the beetle, it is necessary to separate the sexes in the pupal period in order to set up a population of known imago composition.

Fortunately, disease has not interfered with the experimental work so far, although White (1923) and Riley and Krogh (1922) have reported two different infectious diseases of *Tribolium*.

The value of *Tribolium* as an experimental animal was demonstrated by Chapman's (1924) study of the effect of nutrition on growth and development. He found that food is not so important a factor for survival and growth as for metamorphosis, for which the proper nutritional requirements have to be met. He decided upon whole wheat flour as the best culture medium and incidentally found that frequent handling greatly increased the death rate. As a result of this experiment, Chapman has used whole wheat flour as the culture medium in all the work he has done since.

Chapman (1928) made up a series of cultures each in an individual bottle with 32 grams of whole wheat flour and alike in all respects except that they were started with initial populations of 2, 4, 8, 16, 32, and 64 beetles per bottle. He then took a census of each of these cultures at intervals for a period of 139 days and found the interesting result that at the last count (made on the 139th day) the six cultures had pretty close to the same number of beetles, the average being 43.97 ± 2.88 individuals per gram of flour. A second experiment reported in the same paper consisted of placing one pair of newly emerged beetles in 16, 32, 64, and 128 grams of whole wheat flour and following the population growth in each. Gause (1931) analyzed these data and found that in each case the growth was logistic and reached an upper asymptotic value. The greater the volume of flour, the greater was the upper asymptote of population, a simple exponential relationship existing between those two variables. This was taken to mean that the maximum size obtainable by a growing population in a limited environment is a direct function of the size of the environment. Since the populations started with different numbers of individuals but reached approximately the same maximum density, it necessarily followed that density determined the net rate of increase at some point. Allee (1931, p. 180) plotted from Chapman's data (on the first of the two population experiments just described) the net rate of increase against the initial population per 32 grams of flour. The striking feature he calls attention to is the fact that the cultures started at the lowest population density had the lowest rate of reproduction in the first few days, that there was an optimal initial density (4 beetles per 32 grams of flour), and that greater densities than this successively lowered the growth rate for the first 25 days at least. This, as he points out, is similar in appearance to Robertson's

phenomenon of allelocatalysis in the protozoa. Chapman's experiments were run on such a small scale that the results were by no means conclusive, so Park (1932) repeated the experiment, counting the eggs produced as well as the larval, pupal, and imaginal population and obtained the same general result. He found that 2 pairs of beetles in 32 grams of white wheat flour produce more eggs per female day in the first few days than does one pair of beetles in the same volume of medium but that crowding above this point results in a progressively lower fecundity. In all cases, as the population grows the fecundity declines until a state of equilibrium is reached where the population remains fluctuating about its asymptotic value.

Park was wise enough not to follow Robertson's lead and postulate some mysterious "X-substance" to explain this optimal density phenomenon. Instead, by combining the results of two cleverly conceived lines of investigation, he was able to arrive at a satisfactory first approximation to complete solution with a minimum of assumption. First, it was found (Park, 1933) that while virgin females will lay sterile eggs, copulation greatly stimulates fecundity and recopulation increases it still further and also increases the percentage of the eggs that are fertile. Secondly, he found that adult beetles eat their own eggs; males, virgin females, and fecundated females all eating them at approximately the same rate, while this practice has no effect upon the fecundity of the females. From these facts he argued (Park, 1933) that up to a certain point increasing the population density would increase the fecundity by increasing the frequency of copulation, while increasing the population density would reduce the net production of eggs by increasing the number eaten. The resultant of these two factors which work in opposite directions might be expected to produce the observed results, an optimal density of population for maximum net egg production per female beetle.

Having developed a reasonable theory to explain the beneficial effects of crowding up to the optimal point, it was natural to turn next to a further investigation of the factors underlying the depressing effect of higher population densities. Chapman (1926) showed that when *Tribolium* are rubbed or otherwise irritated they give off a gas which smells like an aldehyde, irritates the eyes and nose, and turns flour pink. An old culture which has been kept in a closed incubator for a long time always has the characteristic odor of this gas. Larvae exposed to a high concentration of the gas become deformed in about 10 per cent of the cases, the deformity usually taking the form of the larvae developing wings in the molt ordinarily producing pupae and then never developing further. Pupae so exposed sometimes develop into deformed adults. No such deformities have ever been observed in ordinary cultures, but it is quite probable that in old, crowded cultures the gas is present in sufficient quantity to have deleterious effects of a somewhat less drastic nature. Just why it should be formed is not known, though the idea that it may be used as a defensive weapon is the most obvious guess. Park (1934a, 1934b) started to attack the problem in a long series of papers, which are still being added to, by determining the effect of "homotypically conditioned flour" upon *Tribolium*. These experiments closely parallel Allee's work on the conditioned environment for other organisms. Flour is said to be "conditioned" when a large culture of *Tribolium* has lived in it for a long period of time. Mated female beetles placed in it laid significantly fewer

eggs than they did in fresh flour, other environmental factors being the same, and the egg production declined as long as they were left in it. A part of this additional decline with time is accounted for by the fact that fecundated beetles lay fewer eggs as they grow older, even in fresh flour. The beetles which had had their fecundity reduced by conditioned flour recovered their normal rate of egg production when returned to fresh flour if they were not left in the former too long. The conditioned flour apparently did not affect their fertility. Park (1935a) found that origin females lay three times as many eggs in fresh flour as in conditioned flour. On the other hand, the cannibalistic tendency is less in conditioned flour. Male beetles were used to test this point (as they eat eggs at the same rate as females and do not complicate matters by laying eggs), and it was found that they eat only half as many in conditioned flour as they do in fresh flour, other factors being equal. Still another effect of conditioned flour was to increase the time and variability in the time of larval metamorphosis. To determine how early in the life of a new culture the autoconditioning of the flour would produce an effect on the beetles, Park (1936b) set up five cultures alike except that the medium was fresh flour mixed with the proportion of 0, 25, 50, and 75 per cent conditioned flour. He found that the 25 percent conditioned flour culture produced significantly fewer eggs than the entirely fresh flour culture, there was no noticeable difference between the 25 and the 50 percent cultures but the 75 percent culture produced still fewer eggs and the 100 percent conditioned flour culture produced fewer eggs than any of the others. He concluded that the effect of conditioning on fecundity sets in "before the culture has reached a decadent state" but that it has no effect on fertility at any stage. Park and Woollcott (1937) repeated and added to this work, the principal new finding being that conditioned flour increases the mortality of larvae. Strangely enough, Park (1936) could find no significant effect of conditioned flour on either the oxygen consumption or on the weight of the adult beetles. An interesting point was to determine whether starting beetles in conditioned or partly conditioned flour would in effect increase the biological age of the cultures, as should be the case if conditioning is the major bad effect of overcrowding. Park (1938) set up 200 bottles each originally with 32 grams of flour and 2 pairs of *Tribolium;* 116 of them had all fresh flour, 36 had 5 to 10 percent conditioned flour, 36 had 15 to 25 percent conditioned flour and the remaining 12 bottles had 100 percent conditioned flour. A year later he examined all the cultures for dead as well as living beetles. There were no living beetles at all in the cultures made up with 100 percent conditioned flour and in the other cultures the total populations were in inverse proportion to the original amount of conditioned flour. It might therefore be concluded that the effect of conditioned flour was to "age" the culture and bring on decline and extinction earlier. Park (1937 and 1934b) and Ford (1937) have written general discussions of all this work up to those dates.

A fact of perhaps very considerable importance in a declining population was discovered by Holdaway (1933) who reported that he could vary the sex ratio by starving the larvae. Under ordinary conditions 51 to 52 percent of the pupae, and presumably of the adults also, are males. Holdaway obtained larvae within 12 hours after they hatched from the eggs, placed them in a moist chamber without food for one, two, or three days and then transferred them to fresh flour.

The larvae which were starved one day gave rise to 54 to 58 percent male pupae, somewhat, but not significantly, more than the ordinary proportion. But larvae starved two or three days gave rise to only 45 to 50 percent male pupae which was significantly less than in the controls. The highest observed mortality in any of Holdaway's series was 6.9 percent from the larval to the pupal period and this is not great enough to account entirely for the observed difference in sex ratio. Possibly a selective mortality combined with chance does account for it; otherwise, the only apparent alternative explanation is that starvation produced an actual sex change in some individuals. It would be interesting to know if the sex ratio of larvae developing in old densely populated cultures is likewise changed, but this has not yet been determined.

Park (1938) has recently presented some data on the effect of crowding *Tribolium* during the larval period. He reports that larval and pupal mortality and the duration of the larval period are increased and the weights of pupae and imagoes developing from them are less when larvae are subjected to crowding. However, if the culture medium of a crowded larvae population is changed every 48 hours none of these effects are seen.

Chapman is a strong advocate of applying quantitative as well as qualitative methods to biological investigations, an idea first forcefully introduced into this country for experimental work by Pearl in his studies on poultry and later on *Drosophila* as will be described further on in this paper. All population work is essentially quantitative in nature and the answers to many of its problems depend upon a comparative evaluation of the effect of qualitatively different variables. It would be desirable then, to have a single yard-stick on which to measure, let us say, all environmental factors. In this connection Crew (1937) has recently suggested that the sex ratio might be used as an index of socio-economic welfare in human populations. Chapman introduced his term, "biotic potential," particularly for use as just such a yard-stick. He says, (Chapman, 1928):

"It is suggested that environmental factors be measured in terms of their effect in reducing the potential rate of increase. Thus all factors may be measured on the same scale and their values compared directly."

This would be all very well if we were interested in nothing except the growth rate over a limited period, which is certainly a matter of prime importance to population physiology, or if we could assume that this is such a key phenomenon that all other factors could directly be determined from it. As we shall see later with *Drosophila*, one environmental factor, such as low temperature, may lower the net rate of increase and slow down the rate of development while at the same time cause the animals to grow larger and live longer, while another factor, such as overcrowding, may also lower the net rate of increase and slow down the rate of development but produce smaller animals which do not live as long. In this case, the net rate of increase would be a very poor scale indeed on which to compare the general biological effects of the two different environmental factors.

On the other hand, the mathematical formulae based on what Chapman calls the "biotic constants" may give a clearer idea of the relationship existing between different population variables and as predicting formulae may be of use in testing out various hypotheses. Chapman (1933) and Chapman and Whang (1934), for example, have worked with "synthetic populations" of adult male beetles only

to which they added eggs at the same rate at which it was calculated they would have been laid had half the beetles been females. In the latter paper an experiment is reported in which four bottles each with 32 grams of flour were started, three of them with 16 male beetles and one control bottle with 8 male and 8 female beetles. Eggs were added to all the male bottles at the calculated rate of oviposition for 8 females at this density and temperature. On the 33rd and 34th days, when 1,455 eggs had been added to each "synthetic population," 142, 150, and 141 eggs were found remaining in these three cultures while 135 were found in the normal control culture to which none had been added. The closeness of the results would indicate that the calculations on rate of egg eating, and rate of hatching of eggs, etc., the "constants" on which the number of eggs added was based, were not far from being correct.

The degree of accuracy with which predictions can be made naturally depends upon how closely the same results can be duplicated in successive experiments. Pearl's *Drosophila* experiments were customarily carried out with very large numbers, usually thousands, of flies which were also of quite definite and known genetical make-up. Using the same stock of flies, it is practically certain that the same relationships would obtain again if the experiments were repeated. That is to say, the growth curves would still be logistic and the same functional relationship would exist between fecundity and density of population, etc. Chapman, Baird, and Lillian (1934) criticize the use of *Drosophila* as an experimental animal on the basis that its biotic constants are too unstable to permit the use of them in mathematical formulae and point out the superior advantages of *Tribolium* in this respect. They cite a paper from this laboratory by Alpatov (1932) to show how unstable *Drosophila* is especially in respect to fecundity.

Philosophically Chapman's point seems a feeble one. *Drosophila* would appear to be quite as important an organism in the scheme of cosmic organization as *Tribolium*. Certainly it is quite as desirable and significant to know about the biology of one as about that of the other. Furthermore there appears no reason to manipulate any "constants" that may be found for any other purpose than to obtain hints for future experimental investigation. *Drosophila* populations do in fact show certain biological relationships which are constant on experimental repetition: Pearl and his associates have never attached any special significance to the arithmetic values of particular points picked from their fitted curves, which values might be called "constants" by Chapman's definition. They were not interested in selling insurance policies to flies or beetles either, but in showing sequences of events which when general and repeatable can be considered as biological principles, and this they have done. Certainly there are advantages in working with an animal which gives close to the same reaction every time it is treated in the same way. But it has yet to be demonstrated that *Tribolium* is measurably superior to *Drosophila* in this respect. Chapman, Baird, and Lillian (1934) report that in an experiment in which they placed 100 *Tribolium* eggs in each of two bottles at 32°C., 27°C., 22°C. and 17°C. the larval and pupal periods were about the same in each two bottles at the same temperature. As will be shown in another paper, the time for development is also very constant for *Drosophila* at low densities but has a large standard deviation in crowded bottles, and Park has shown that in conditioned flour the

variability for this factor is greatly increased in *Tribolium*, also. The former authors give data for the fecundity of 15 mated females for just the first 13 days out of a long life span and there appears to be a considerable variation from day to day for the same female beetle, and some of them laid twice as many eggs as others during this period. This, and the data of Park on *Tribolium* fecundity, do not appear to indicate that *Tribolium* are especially constant for this factor. But the stability of mean values depends quite as much on the numbers involved as on the standard deviation, and in this respect there is an enormous advantage in favor of *Drosophila*, even if it is a bit more variable, which is doubtful.

(To be concluded)

ON HUMAN SOCIAL BIOLOGY

I. PRELIMINARY REMARKS

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The study of the relations between man and other men can and has been undertaken in a variety of ways. Sociology, ethnology, psychology, psychiatry, and epidemiology deal with certain aspects of such relationships, some in a more general and theoretical fashion, others in a more particularized and specific manner. Notwithstanding differences in methodology, all of these branches of science have the same aim: to increase the knowledge about a particular kind of activity of *Homo sapiens;* and, as a consequence, to achieve the understanding of means by which man's sojourn on this planet may be made more agreeable and pleasant. This is also a fundamental objective of human biology, one of the most recent additions to those branches of science concerned directly and primarily with man. In the words of Pearl: "Human biology has for its purpose and ultimate objective the *synthesis* of the knowledge of the *biology* of man that has been acquired in the course of the development and evolution of a number of separate special disciplines, notably anatomy, physiology, anthropology, psychology, genetics, sociology, economics, history and biostatistics" (Unpublished course lectures, cf. also, Pearl, 1924, 1935b). This synthesis resolves itself into an integration of the multiple facets of man (which appear from the analytic procedures of the above disciplines) among themselves and with the basic biological constitution deriving from his zoological rank. This process of integration has already been successfully initiated for certain aspects of man's manifold personality. We need only recall, as an example, the work on somatological constitution which attempts to measure the degree of consilience between the anatomical, physiological, and psychological personalities of man. Not so advanced is that part of human biology which refers primarily to social behavior. Responsible for this lag in the development of human social biology is the lack of a satisfactory and productive approach to the problem of determining the elements, biologic or otherwise, of social behavior. A discussion of this question is the primary purpose of this paper which is to serve also as an introduction for the future presentation of the results of some original investigations on the subject.

ANIMAL SOCIAL BEHAVIOR AND INSTINCTIVE BEHAVIOR OF MAN

Darwin's *The Descent of Man* closed with the phrase "Man still bears in his bodily frame the indelible stamp of his lowly origin" (p. 619). It is difficult to realize now that this thought was set down in defiance of ideas prevalent less than 70 years ago. That man is an animal and as such alone possesses certain attributes and behavior characteristics is a concept

accepted today so generally by students of biological sciences that its restatement acquires the quality of redundancy. Yet its explicit statement is less than a century old and all its implications, particularly those referring to man's social behavior, have not been at all seriously explored. This is not surprising because there is always a lag between the enunciation of a principle and its general application. It is remarkable however that the disregard for the biological foundation of man's activities should include also a neglect of the importance of his morphological and physiological characteristics as factors in behavior. A glance at the textbooks of sociology is sufficient to show that very few give more than one or two paragraphs to the so-called 'drives' or 'urges', and generally no mention is made of the fact that man's activities are subjugated to the requirements of his physical organism. These needs are real and tangible and are altered only in a minute degree if at all by the superorganic manifestations. Satisfaction of these needs or biological urges is the only categorical imperative for the existence of man as an individual or as a species. When it is a matter of group survival, the importance of religious principles can give way to Henry of Navarre's answer that Paris was well worth a Mass. And when slow starvation seems inevitable, even the so-called filial and parental instincts are repressed by the hunger which seeks alleviation in cannibalism as Gantt (1937) and others have reported from Soviet Russia. It is recognition of these fundamental facts that gives value to the population theory of Malthus, the historical materialism of Marx, and the psychoanalytic approach of Freud.

In common with all living creatures, man demonstrates those qualities which Pearl has summed up as follows: urge for individual survival, urge for reproduction, variability. The multitudinous manifestations of these qualities or their relationship with the differences in structure and function of the many kinds of living creatures cannot be discussed here. Based on the elements in common, one approach to the study of human social biology is that of animal experimentation and observations.

It is this approach which has been responsible for much of the recent progress in physiology, medicine, psychology, genetics and other branches of sciences. For the study of human social behavior, however, it has not proven of equal value, although since animal behavior has more and more occupied the attention of biologists precise observations have been recorded that are unquestionably useful for the student of social sciences. From the classical observations of Espinas (1878) to the more recent ones of the late William Morton Wheeler (1928b, 1933, 1937) there is available information that is important probably not so much for its immediate usefulness in the solution of human social problems but mostly as a means of understanding clearly what they are all about.

Wheeler, for example, in the numerous publications covering long years of study, has critically examined his own observations and those of others on the social insects, the ant in particular, to arrive at a comprehensive portrayal of their social behavior. There are many deductions important for our purposes to be made from his observations. The tendency to sociality is manifest by these insects in a manner weaker but more constant than the sex and hunger cravings. Society is organized as a mother-family pattern with integration around the original nest-mother varying in degree. In some cases any invader who successfully ousts the

nest-mother is accepted without overt hostility, in others it is repelled. The complexity of the social organization varies and with it the differentiation between castes, both morphologically and functionally. The more complex is the social organization, the more complex appear to be the societal functions and greater is the differentiation between the castes. The differentiation of the castes may be slight and conditioned by the environment, or it may be striking and presumably genotypic in nature.

If we pass from insect societies to the less extensive observations on sub-human primates, utilizing Zuckerman's (1932) report based principally on the Hamadryas baboon colony of the London Zoological Garden, the following facts seem important. The sexual element, both homosexual and heterosexual, prevails in the social interrelations. The family unit is a product of the dominance of a male over the female and over other males. The family integration depends entirely upon the continued dominance of the over-lord. Societal functions vary within limits and are characterized mostly by their absence. What there are result from a series of relationships of a dominance-submission pattern between the individuals.

As one ponders these observations and notes the numerous points of resemblance between the overt social behavior of these animals and that of man, it is easily understood why from time to time attempts are made to describe the superorganic manifestations of man entirely in terms of animal behavior. The theory of organic evolution has given a stronger impulse to this way of thinking and there are a number of students of the social sciences who have ventured to trace the evolution of social traits. Kropotkin (1902), for example, studied the phenomenon of social coöperation and its importance in the rise and decline of animal and human societies. He arrived at the conclusion that coöperation is one of the most important if not the only factor responsible for the survival of the group. The fact that Kropotkin's political opinions prejudiced some of his interpretations based on good, bad, and indifferent observations has perhaps worked against an adequate appreciation of his work. Westermarck's (1903) study on the history of human marriage is another example of the attempt to chart the course of the evolution of social institutions. He emphasizes in particular the stable predominantly monogamous attachments said to be observed in sub-human primates and concludes that such is the primeval pattern of human marriage. In later studies, following criticism of the sources of his information, this opinion was somewhat modified. All these and similar studies, aside from the doubtful quality of the observations on which they are based, have little value except as hypotheses which may or may not be useful. This is so because of our ignorance regarding the processes which have led to the human branch of the animal trunk.

From a recognition of the characteristics of the behavior of other animals is derived the concept of instincts on which is founded the social psychology of McDougall (1921). For him, the instincts are native propensities, innate or inherited tendencies of the human mind; variable according to individual and group but probably common to men of all periods and places. They develop under the guidance of intelligence and are modified by the state of culture. He notes in particular, as Russell (1934) has, that instinct is not a purely mechanical process but in its action involves cognition, affection and conation. He recognizes primary and

secondary instincts, the former being characterized by their presence in higher animals and the possibility of appearing in an exaggerated form. The list of instincts which he gives is modified from that of James, and each instinct is accompanied by an emotion by which it is manifested. The instincts mentioned include those of flight, with fear as its corresponding emotion; repulsion, and the emotion of disgust; curiosity, and the emotion of wonder; pugnacity, and the emotion of anger; parental, and the tender emotions; self-abasement and self-assertion, and the emotions of subjection and elation. Reproduction, gregariousness, acquisition and construction are among the less clearly defined instincts, and apparently have no emotion attached to them, according to McDougall. The action of these instincts on social phenomena and individual social behavior is illustrated in a variety of ways. The size of population is regarded as a function of the reproductive and parental instincts. These instincts can be inhibited by intelligence and therefore social sanctions are often necessary to support them. The parental instinct is also manifest in the benevolence shown to the lower classes, aid to the oppressed, etc. Another of the instincts of prime social importance is that of pugnacity because it assures the selection of the fittest, either individual or group. Greater pugnacity is associated with other qualities which lead to a higher degree of civilization. Moreover this instinct is held to play an important rôle in the development of penology and is finally altered into the tendency to emulate. The gregarious instinct has had its primary importance in keeping men together, and therefore provides the stimulus for the development of society in its modern aspect. Religion in its more primitive form, according to McDougall, is a product of fear, curiosity, and subjection. In its higher form it derives also from tender emotions, awe, and gratitude. The instincts of acquisitiveness and construction are not directly social but as the words imply are involved in many social activities.

McDougall's social psychology, only cursorily outlined here, represents the most elaborate attempt to explain social behavior in terms of elementary biological factors. It falls considerably short of the mark and this failure demonstrates the essential difficulties and limitations of this direct biological approach to the problems of human social behavior. It is not the place here to enter into the controversy regarding the existence of instincts. The extreme position taken by Watson (1930) on this subject is curious, since he is forced to admit the inheritance of physical traits but not of psychic ones, and yet observes unlearned tendencies of a decidedly psychic nature. The whole controversy is not very inspiring and apparently useless, as any one can see from the sober factual study of the subject made by Russell.

There is another weakness in the position taken by the school of instinctive social behavior. In the first place it has not been shown that all the social reactions of animals including man are instinctive in the sense defined by McDougall. Wheeler's (1933) words on this point, when he discusses the behavior of the solitary bee who builds the cell and provisions it for the larva which is as yet still undeveloped in the egg, are worth remembering.

"All these apparently purposeful arrangements are indeed wonderful, but so are the intricate devices which insure the nourishment and protection of the embryo in the seed of the higher plant or of the foetus in the uterus of the mammal, and yet neither the botanist nor the embryologist imagines that he is

gaining any insight into such physiological phenomena by attributing them to 'maternal instinct'. The term is quite as useless when applied to the behavior of the mother wasp, bumble-bee or ant, which is acquainted with her eggs and larvae. We may assume, at least till proof to the contrary is forthcoming, that the eggs and young larvae 'impose themselves on the parent', that is, act as stimuli which elicit the nursing responses, because they emit specific agreeable odors or secretions that makes these responses irresistible" (pp. 148–149).

In the second place, it has never been made clear where and how McDougall obtained the evidence of the existence of those human instincts that he mentions. Certainly not from animal observations because the list would be different, as is evident from the cited studies of Wheeler and Zuckerman. And certainly not from human observations since what specific ones there may be cannot as yet be discerned from the behavior characteristics imposed on man by his environment, social or otherwise.

These are defects of a theoretical and formal nature. The main shortcoming of McDougall's social psychology is that it does not establish in any way the continuity between postulated instinct and the concrete social phenomenon. Even if the list of given instincts is correct the way is not possible except by speculative acrobatics to follow the development of the reproductive instinct, or the instinct of acquisitiveness, or what have you, into the various forms of the institution of marriage or that of prostitution, for example. This illustrates the fundamental limitation inherent in the attempt to reach an understanding of human social behavior simply from the study of animal sociology. Such a limitation derives from the differences between man and other animals. Man possesses the ability to formulate and express abstractions. He is, as Pearl (1937a) aptly says, a time-binder, an organ-adder, and an environment-changer. He not only responds to internal physiological stimuli and to the external physico-chemical ones, but he also thinks and talks about them and in consequence initiates a whole train of factors which go under the name of social conditioning. By inductive reasoning starting from the observations of animal social patterns it is impossible to construct anything but the vaguest generalities about the biology of man's social actions. It is necessary instead first to disentangle from the complexity of the relations between man and other men the stable elements, the manifestations of his human nature which include those derived from his "lowly origin".

THE INDIVIDUAL AND THE GROUP

Menenius Agrippa, as Livy relates, convinced the seceding Roman plebeians of the justice of the caste system by drawing an analogy between the functioning of the individual and that of the social group. Many centuries later Herbert Spencer drew the same analogy in attempting to construct a theory of social transformation parallel to that of organic evolution. Spencer's illustrative analogy as well as the inferences he derived therefrom were to leave their mark not only on human sociological thought, expressed by what Sorokin (1928) denominates the bio-organismic school, but also on social psychology and animal sociology.

Society, notes Spencer (1921), is an organism composed of individuals that like cells are interdependent in activity and can survive the destruction of the total organism. The cellular structures of the social organism are also differentiated relative to form and function, and the organism like the individual society passes through the phases of growth, decline, and death.

Such an analogy is somewhat superficial and probably its main value is a political one, in the sense used by Agrippa. The general applicability of this concept to concrete phenomena apparently depends in great part upon the degree of functional and structural homogeneity of the elements composing the organism and the kind of interrelationship which unites them. In the realm of human social behavior this principle could perhaps be utilized best in the study of groups composed of fairly homogeneous individuals with well-defined functions and linked together by strong and endurable ties.

The influence of Spencer's concept is seen in the development of the theories of "crowd" or "mob" psychology and of social emergence. These theories assume, to a varying degree, that the social group is something that emerges from its component members, in the same fashion that the individual organism is something more than and different from the mere summation of its cells. Le Bon (1896), for example, believes that when an association is formed, new characteristics are acquired different from those of the single individual; a collective mind is created which feels and produces actions in a manner which can be totally unlike that of the members of the group. This process is essentially attributed to contagion or imitation and suggestion. Since this process is essentially attributed to contagion or imitation and suggestion it follows that actually the crowd acts according to the ideas or feelings of those individuals who are being imitated and as a group it must be held together for a time sufficiently long to allow the suggestions to operate.

More cautious, although not fundamentally different, are the views of Wheeler (1928a) who discusses this matter primarily from the standpoint of social evolution. For him the formation of the group gives rise to emergence which is "*a novelty of behavior* arising from the specific interaction or organization of a number of elements", and besides is "neither the manifestation or unveiling of something hidden and already existing, . . . nor some miraculous change" (p. 14). In justice to this author, it must be added that he does admit that the emergent pattern of an association depends also upon the functional peculiarities of the component organisms, a statement logically incompatible with the previous definition of emergence.

The main factual foundations for the maintenance of a theory which postulates that a society is an emergent entity, derive from the observations on the group behavior, especially of groups of a temporary nature, apparently so divergent from the usual behavior of the individual participants. Massacres, lynching and similar violent and sanguinary actions on their face seem to result from the transitory association of erstwhile law-abiding, peaceful people. From such facts it would seem justifiable to deduce that the element of association is responsible for the group behavior. It also would appear justifiable to assume that imitation or contagion, as Le Bon prefers, can be a stimulus for the group action, especially since students of animal behavior (Espinas for example), have long ago described its mechanism in other animals. In the same way, suggestion might well be considered an important factor from what the psychiatrists have taught us.

The theory would seem plausible except that further analysis of this type of phenomena reveals that the apparently peaceful, law-abiding citizens who participate in a lynching, let us say, have peculiar characteristics which distinguish them from other peaceful, law-abiding citizens.

Sighele (1895), who has discussed the matter in detail from the standpoint of criminology, ably points out this fact when he compares the differences in the composition and in the action of the mobs which revolted in Paris in 1750 and 1793. From such historical observations and the examination of criminal case records he is led to conclude that neither imitation nor suggestion alone can be held responsible for the criminal acts of a mob, in particular of one formed at short notice. Rather these acts appear to be due to the psychic and physiologic status of the members of the group at the moment, and their interrelations with particular reference to the domination of some individuals over the others. The main facts about the usual form of Negro lynching by whites indicate that this view is substantially correct. The following conditions must be satisfied before a lynching is possible: (1) The subject to be lynched must be a Negro whose alleged victim is white; (2) the crime must be committed where the sentiment against Negroes is strong; (3) the lynching mob must share the sentiments of the locality; (4) none of the dominating personalities of the group is opposed to murdering a Negro; (5) the dominating individuals of the group are able to arouse the emotions of the uncertain majority; (6) the members of the mob are physically capable of committing the lynching. Unless such a combination of elements is formed there will be no lynching, hence lynchings are confined to certain localities and occur sporadically. A similar analysis of other group activities will lead to the generalization that any social phenomenon results from a particular type of interaction between certain individuals and this interaction depends upon the kind of individuals composing the group.

In view of these considerations it is possible to define a human social group in general as being an association of persons who temporarily or permanently possess one or more attributes, functions, or characteristics in common, no matter how much they may differ otherwise. A nation, for example, is an aggregate of diverse individuals who either through accident of birth, descent, migration, capture, etc. are socially constrained by a set of laws and mores. A scientific society, instead, is composed of diverse individuals who are overtly interested in some branch of science and selected either through merit, or simply through the payment of certain fees. A family, on the other hand, usually consists of two types of individuals, those who form the marital union, the nucleus of the family, and those related to each or both of the partners through inheritance or marriage. Thus it is seen that an individual may participate simultaneously to a variety of groups, and his inclusion into a group is due to a multiplicity of causes, ranging from mental qualities to the accidental meeting of an ovum and a spermatozoa.

The qualities of the individuals comprising the group determine the group, and conversely the group or rather the other individuals exercise a certain amount of influence on the individual. In general, emphasis by the sociologists has been placed on the effect of "society," the "laws" and the "mores" on the individual. But this "society" is only all the individuals, the "laws" and the "mores" are products of all the individuals, and all of these are to some extent influenced by the presence and action of any particular individual. The discussion of the effect of family training on the child implicitly assumes that the latter is a plastic thing which is there to be modelled at will by the parents. Such an image is far from reality because it does not account for the unlearned qualities of the child, nor for

the fact that the child's behavior may affect the parents in such a way that they are unable to carry out a program of instruction or discipline. The failure of the penal systems of the past and present, as the observations of the Gluecks (1937) show, are again evidence of the inability to take into account the individuals on whom the system is to be used. In the light of the discussion so far the conclusion seems warranted that the study of the social organism reduces itself to a study of the individual, and the elements that enter into the interaction between individuals.

STABLE FACTORS IN SOCIAL RELATIONS

One of the most important characteristics of man which he shares with all living creatures is variability. It is manifest in all his traits, morphological, physiological and psychical including sociological. There are however limits to this variability due to the innate or acquired constitution, to the environment, or to both. To exceed, if possible, or to approach the limits of the range of variation places the individual in a position apart from the remainder of his group. If in an individual the body temperature exceeds 99 degrees F. he is no longer among the persons in good health, if it exceeds 104 degrees F. he risks being no longer among the living persons. Similarly, in our civilization if a man commits murder and is caught he loses certain civic privileges and is no longer classed among the law-abiding persons. If during a war a man should refuse to participate he also loses certain privileges and is no longer a patriotic citizen. In these last examples the individual has exceeded the permissible limits of the range of variation of those specific social actions. The limits to individual variability in action of direct or indirect social import constitute the material that forms the object of sociological investigations. Laws and written codified regulations are one type of social factors that determine the permissible range of variation in the relations between persons. They represent the highest development of rationality and rationalization in the attempt by the group to limit individual social actions. They are, however, only the specific manifestations of the class of phenomena which goes under the name of customs, or mores, or folkways, the universal limits of conduct imposed on the individual by those composing the group. They are responsible for the peculiarities of man's social behavior which in its uniformity, persistence, and mostly in the apparent lack of conscious effort resemble closely that of other animals. This fact has not escaped Sumner (1906) who has given us what is probably the most admirable description of the mores. He says (p. 4):

> "The folkways, therefore, are not creations of human purpose and wit. They are like products of natural forces which men unconsciously set in operation, or they are like the instinctive ways of animals, which are developed out of experience, which reach a final form of maximum adaptation to an interest, which are handed down by tradition and admit of no exception or variation, yet change to meet new conditions, still within the same limited methods, and without rational reflection or purpose."

And further on, in summarizing the whole varied forms by which the mores operate in the relations between the individual and other individuals Sumner notes:

> "The relations of men to each other, when they are carrying on the struggle for existence near each other, consist in mutual reactions (antagonisms, rivalries, alliances, coercions, and coöperations), from which result societal concatenations and concretions, that is, more or less fixed positions of individuals and subgroups towards each other, and more or less established sequences and methods of interaction between them, by which the interests of all members of the

group are served. The same might be said of all animals. The social insects especially show us highly developed results of the adjustment of adjacent interests and life acts into concatenations and concretions. The societal concretions are due to the folkways in this way,—that the men, each struggling to carry on existence, unconsciously coöperate to build up associations, organizations, customs, and institutions which, after a time, appear full grown and actual, although no one intended, or planned, or understood them in advance. They stand there as produced by 'ancestors'. These concretions of relation and act in war, labor, religion, amusement, family life, and civil institutions are attended by faiths, doctrines of philosophy (myths, folklore), and by precepts of right conduct and duty (taboos)." (Pp. 34-35.)

The folkways are concerned in all aspects of the social activities and as Sumner shows they take different forms according to time and place. Customs of dress, eating, and amusements, morals, religious rituals, types of government are all manifestations of the mores. Taking as point of departure the concept of the mores and the varied manifestations of the folkways, a logical sequence seems to be that of inquiring into the factors present in the single individuals and the group which make the mores different in their form and intensity; or in other words, to investigate the circumstances responsible for a reduction or increase in the range of variation of individual social actions. Sumner has not attempted this inquiry; other investigators have instead sought the origins of the mores or their manifestations, some with the help of animal biology as has been noted, many with an assortment of preconceived notions; still others in considering the social institutions and laws have overlooked the unconscious element in the formation of the original mores. Among students of social sciences, Pareto has made the most successful effort to deduce from the conglomeration of social phenomena certain basic elements of social interrelation. Since his work represents from the standpoint of this discussion the most important contribution on the subject it deserves to be given as thorough an appraisal as is possible in the brief space available. Pareto (1923) begins his study of social phenomena by making a distinction between logical and non-logical actions, defining the first as those actions that experimentally, and for the individual who commits them, tend toward one and the same objective. Non-logical are those actions which are committed with a purpose not experimentally or factually evident. This classification depends then entirely upon the degree of knowledge that is possessed at the time about a particular activity. Thus, fifty years ago to shoot a cannon as a means of dissipating yellow fever would have been considered a logical action since it was a consequence of the supposed knowledge of the day; now it falls under the heading of non-logical actions. On the other hand, according to the lights of fifty years ago, the idea of flying with a heavier-than-air machine was absurd; today it is not. The concept of relativity which he introduces in the definition of these terms as well as in others he uses is one of the most significant and as yet so little appreciated qualities of Pareto's work.

In a manner reminiscent of Sumner, Pareto emphasizes the non-logical aspect of social actions. With extensive and detailed historical facts he gives convincing proof of the preponderance of non-logical actions among societal manifestations. He differs in one respect from Sumner because the latter postulated utility as a factor in the origin of the folkways, while Pareto sees no good reason for the interjection of this element.

Having demonstrated the importance of non-logical actions in social phenomena Pareto proceeds further to note that the action of man is accompanied by an explanation intended to establish the

rationality of the act. In this, man makes use of vague undefinable terms and the clichés of his civilization. The failure to recognize that the logical or pseudo-logical explanation, the theory, does not always precede the action has caused confusion in social sciences, Pareto observes, since a great deal of research has been wasted on trying to show that the action is a logical manifestation of the theory.

Now we come to the most important part of Pareto's system. From the examination of the phenomena he finds that all social manifestations consist of a variable and incidental part (the rational explanation) and a constant element (the motivator of the action). This fundamental psychological factor is neither an instinct nor a sentiment. Sorokin thinks it has the properties of Allport's prepotent reflexes but Pareto explicitly leaves the matter of its nature to the psychologist. This constant factor is given the name residue, the variable one is called derivation. The derivations include all those verbal arguments used to support a thesis: authority of person or thing such as the Bible; metaphysical and legal entities—nature, democracy, social contract, etc.; verbal proofs such as flat statements, or arguments about individual or social utility. Illustration of the reasoning adopted in analyzing a social phenomenon is given by the following example. Baptism is a Christian rite to cleanse the original sin and water is used for the purpose. Water was also employed in the Roman ceremonies of purification. Thus one could say that in purification rites water is employed because of the association between water and cleansing. Additional information on the subject reveals that besides water other things such as blood, mud, and sticks are used in purification ceremonies. The means employed and explanations advanced for their use are the variable and incidental elements of the phenomenon according to Pareto, the constant factor is the complex of feelings and beliefs which assumes that the lost spiritual integrity of the individual can be restored by the combination of certain practices.

Pareto arrives at six broad categories of residues. The first is that of the residues of *combinations*. Under this heading he includes the constants of the whole series of social actions that results from the mental processes of associations of entities—things, persons and words—with no logical connections between them. Widespread social activities are included here such as those which derive from luck—lucky numbers and persons, the evil eye, etc.; theogony and mythology; political slogans; religious rituals. These phenomena are the products of the inventiveness of the human mind without the benefit of intellectual superintendence. The second category of residues are those to which Pareto has given the name *persistence of aggregates*. These concern those actions which demonstrate a desire to maintain a *status quo*. They are probably best illustrated by the show of attachment to one's birthplace, home, group, ideas, ways of living, or one's dead. Conservatism could probably be another name for the tendency manifested by these actions. A third class contains the residues of *manifestations* and includes the constant element of the external acts derived from emotions and sentiments. Parades, processions, all the forms of man's religious, political and patriotic exaltations are grouped in this class. In the fourth class of residues, those of *sociality*, are included the constants of those non-logical actions which serve as the rules for the intercourse between persons. The need for conformity, pity for some and cruelty directed against others, benevolence for the weaker, loyal-

ty to the superior are the sentiments associated with the type of actions included here. Another category includes the residues of *integrity*. These are manifest by those actions taken in defense of the so-called interests; property, family, country, etc. They are evident in such contradictory activities as the fight for equality and that against revolutions. This class of residues contains therefore those that stimulate active movements while those included among the residues of persistence of aggregates stimulate a passive resistance to the same type of situation. The sixth and last class of residues is the *sexual*. In the formation of this class Pareto demonstrated unusual acumen since he included not only those activities which are the direct consequence of the expression of the sexual urge but also those which represent the sexual inhibitions, repressions, and perversions, that is, such phenomena as morality, asceticism and flagellation.

This is the nucleus of Pareto's system. He believes that these residues are present in every individual but with different intensity. The social actions and interactions observed in a society result from the variation of the strength of the several residues among the members of the group.

Without doubt the system of classification by which he arrives at his residues lacks an organic basis. But it is entirely phenomenal and avoids the futile attempts to separate nature and nurture, unlearned, and conditioned factors. However, before this classification can be of practical utility or acceptable a quantitative analysis must demonstrate more precisely than Pareto has done how the categories are formed and if they are at all comprehensive. That this system could be improved upon was realized by Pareto himself if not by his devoted desciples, who, in general, have limited themselves to loud hosannas about the master's work.

It is not actual classification of residues which is of importance but rather that Pareto has shown how the complexity of social phenomena could be reduced to a point where it seems possible to assume that by means of animal observations and experiment, a clearer understanding of the fundamental factors of human social behavior can be obtained.

As observations on lower animals clearly show, the stable elements in their social behavior can be objectively studied and the search for causal factors therefore theoretically rests on a foundation of precise knowledge or that can be made so. The stable elements of the social activities of man, on the other hand, cannot be always studied with the same degree of precision because in the majority of cases they are not clearly to be separated objectively from the variable and incidental elements. This fact is responsible for the poor showing of those attempts to apply directly to man the observations made on animals. It would seem that Pareto has shown that it may be possible to eliminate the incidentals and to arrive at a view of the fundamental characteristics. If he is correct then it means that for the study of man's social behavior, the same methods that have proved so efficient in other branches of human biology can be utilized.

CONCLUSION

In sum, the study of human social behavior is here envisaged along the lines, for example, of physiology where the physician or the physiologist makes his observations on man, but from animal experiments derives the knowledge necessary to elucidate the observations. Already there exists valuable work on animal social experimentation such as that of Allee (1931, 1938), for example, but just

as is the case relative to purely observational work on animal sociology, such knowledge for the time being cannot be extended to man. This is so because the students of human behavior have yet to provide observations adequate for the coöperative enterprise. From a consideration of the progress in other branches of human biological sciences there is reason to believe that only when this coöperation is achieved will it be possible to reach a more definite understanding of man's social activities. From all that has been said before it appears that the effectiveness of the efforts directed toward this objective will depend in great part on how clearly it is realized that the study of human social behavior must be based on concrete elements—on the individuals who compose the group and on their mutual relations. In other words, the social activities of man are not to be looked upon as configurations of geometric points, or as movements of automatons, or simply as the behavioristic responses of animals but instead they are to be regarded as the manifestations of living creatures whose mutual relations reflect to a greater or less degree, at one end and at the same time, their powers of rationalization and their biological constitution. To deduce from these phenomena, accepted in all their complexity, the stable elements of the relations between man and other men is the immediate problem which faces the student of human social biology.

The author takes this occasion to express his deep feeling of gratitude to Dr. Raymond Pearl whose encouragement, advice and criticisms have been of incalculable aid in the preparation of this article.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *1901 East Madison Street, Baltimore, Maryland, U. S. A.*

BRIEF NOTICES

EVOLUTION

CHARLES DARWIN: *A Portrait.* *By Geoffrey West. Yale University Press, New Haven.* $3.50. 9¼ x 6¼; xiv + 359 +8 plates; 1938.

For all too long Darwin's life has been overshadowed by his works, and they in turn have been too largely dominated by one book. Because the *Origin of Species* has affected scientific and philosophic thought more than any other biological book has ever done, an unmerited condition of relative neglect has been the fate of *The Descent of Man*, *The Variation of Animals and Plants under Domestication*, *The Expression of the Emotions in Man and Animals*, *Coral Reefs*, *Volcanic Islands*, *The Power of Movement in Plants*, *The Formation of Vegetable Mould through the Action of Worms*, and the *Voyage of the Beagle*, to mention only a few of his less well-known writings.

The biography of a great man must inevitably consist of much more than a mere bibliography of his writings, but the literary output of a man like Darwin must loom large in any account of his life. Darwin was a man of extreme modesty—even on the celebrated occasion on which he gave his new theory to the world, when Wilberforce and Huxley locked horns over it, he absented himself in order to avoid the possibility of having to defend it extemporaneously before the intellectual lights of Great Britain. To appear in public was extremely distasteful to him. He was a great prophet, but he spoke through his pen. To understand his message one must be familiar with his writings.

But the man himself was something quite distinct from his message. To understand the man it is necessary to consider his ancestry. The author of the present work begins with the two grandfathers, Josiah Wedgwood and Erasmus Darwin, and the first quarter of the book consists mostly of a scholarly presentation of the biography of these two men and their families, particularly Robert Darwin and Susannah Wedgwood, the parents of the propositus.

The life story of Charles Robert Darwin *sensu stricto*, occupies something more than half the book. It is a stimulating and encouraging story, for Darwin in his youth gave little evidence of the genius that characterized his progenitors and which was later to reach its full fruition in him. An impediment in his speech made it difficult for him to meet other people. At Cambridge, where he attempted to take up medical and ecclesiastical careers by turns, he was a failure—and then came the opportunity to circumnavigate the globe on the *Beagle*. At first he met with opposition from his father, who underestimated his son's ability, and from Captain Fitzroy, who did not like the shape of young Darwin's

nose, but the latter's persistence, fortified by that of his Uncle Josiah Wedgwood, Jr. finally carried the day, and the course of scientific thought began to be diverted.

The author of this biography confesses that he undertook the work with a personal prejudice against Darwin, because the latter was such a perfect embodiment of Victorian Morality, but that as the work proceeded he developed a genuine affection for the man. The reader will readily understand this, because as he proceeds he will realize that Darwin was not only one of the most significant characters in the recent history of civilization, but also one of the most appealing. The author has done his work well both as history and as literature, and not its least interesting feature is the glimpses that he gives us of some of Darwin's contemporaries, such as Lyell, Hooker, Wallace, etc. The bibliography covers eleven pages and the index seven and there are eight plates.

FOSSIL ANTHROPOIDS OF THE YALE-CAMBRIDGE INDIA EXPEDITION OF 1935.
By William K. Gregory, Milo Hellman and G. Edward Lewis. Carnegie Institution of Washington, Washington, D. C. $1.00 (paper); $1.25 (cloth). 10 x 6⅞; 27 + 8 plates; 1938.

The findings of the Yale-Cambridge Expedition to the Siwalik Hills are described and compared with other anthropoid material. An excellent study has been made of teeth measurements and many fine plates depict these important structures. The general results are as follows:

In closing, we deem it important to emphasize the following facts: (1) that the extinct anthropoid apes ranged over an enormous area in the eastern hemisphere—from Spain in the west to India and China in the east, and southward from Egypt to South Africa; (2) that the group as a whole was exceedingly variable, at least in the details of the jaws and dentition; (3) that while the Siwalik genus *Ramapithecus* and the South African *Australopithecus* were still simians by definition, they were almost at the human threshold, at least in respect to their known anatomical characteristics.

Nor can we find any convincing evidence that the peculiar features of the teeth of *Sinanthropus* and later hominids (such as irregular folds and wrinkles of the enamel surface of the molars, taurodontism of the molars, the shovel-shaped form of the central upper incisors, the lowness and bluntness of the canines, etc.) are ever anything more than specializations, of later date than the opposite characters found in the upper Tertiary anthropoids of the Siwaliks.

GENETICS

ERBMATHEMATIK. *Theorie der Vererbung in Bevölkerung und Sippe.*
By Harald Geppert and Siegfried Koller. Verlag von Quelle and Meyer, Leipzig. 16 marks (paper); 18 marks (cloth). 9½ x 6½; viii + 228; 1938.

This is an outline of some of the methods of evaluating quantitatively the genetic factors in human inheritance. The author first describes the probability mechanism concerned in the computation of the simple Mendelian ratios and then proceeds to develop the formulae necessary for the study of more complex situations such as occur in man. He illustrates the method of estimating the frequency of a genetic factor in a random population, the estimation of the number of factors involved and of their allelomorphic behavior, linkage, etc. He discusses also and at length the different methods of analysis according to the selection of the sample: family, sibs in general, twins. From the standpoint of theory this book provides useful and necessary information for the student of genetics. Since the formulae are derived by elementary methods, no great knowledge of mathematics is necessary to understand them. However, the applicability of most of the formulae to concrete problems of human genetic research is somewhat limited.

HEREDITY. *Third Edition.*
By A. Franklin Shull. McGraw-Hill Book Co., New York. $3.50. 9 x 6⅛; xvii + 442; 1938.

The current edition (second edition reviewed in Vol. 7, No. 1 of the Q. R. B.) of this work is a worthy successor to its predecessors. It differs from them chiefly in the order in which the contents are presented, the inclusion of an appendix of thirteen pages containing a compact treatise on biometrical methods, a bibliography of eight pages of recent literature, and in being more or less completely re-

written in the light of the advance made by the science of genetics since the last edition appeared. The index has been expanded to eighteen pages. A very useful standard text.

DIE VERERBUNG DER GEISTIGEN BEGABUNG.

By Friedrich Reinöhl. J. F. Lehmanns Verlag, Munich and Berlin. 6 marks (paper); 7.20 marks (cloth). (Outside of Germany 4.50 marks (paper); 5.40 marks (cloth)). $8\frac{3}{4}$ x $6\frac{1}{4}$; 280; 1937.

An interesting treatise, primarily intended for the general reader, but useful to the specialist because of its documentation, on the inheritance of mental endowment. The author discusses the general fundamentals of genetic theory; techniques of genetic investigation in man; the concept and measurement of intelligence in man; the relations of heredity and environment; mental disease; and the mental endowments of races. For data he leans heavily on American recruiting statistics and German material.

MULE PRODUCTION. *U. S. Department of Agriculture. Farmers' Bulletin No.* 1341. *By J. O. Williams, Revised by S. R. Speelman. Government Printing Office, Washington, D. C.* 5 cents. $9\frac{1}{2}$ x 6; 28; 1938 (paper).

A brief treatise on the production and care of mules. Being intended strictly for practical use, it contains no discussion of why some mules are fertile and others are not. A surprising feature brought out is that a good jack for breeding asses is not necessarily a good jack for breeding mules.

GENERAL BIOLOGY

MOUNTAINS OF THE MOON. *An Expedition to the Equatorial Mountains of Africa. By Patrick M. Synge. E. P. Dutton and Co., New York.* $4.00. $8\frac{1}{2}$ x $5\frac{3}{4}$; xxiv + 221 + 93 plates + 1 map; 1938.

FLYING FOX AND DRIFTING SAND. *The Adventures of a Biologist in Australia. By Francis Ratcliffe. With an Introduction by Julian Huxley. Robert M. McBride and Co., New York.* $4.00. $8\frac{1}{2}$ x $5\frac{1}{2}$; [14] + 341 + 32 plates + 4 maps; 1938.

These two books bear eloquent witness to the fact that the days of Gilbert White, William H. Hudson, and James H. Ferriss are not yet over. The writer who can command a good literary style in which to recount what he has seen, and who is gifted with powers of observation to see what others do not, whether in his own back yard or in the uttermost parts of the earth, need never lack an audience.

Much has been written in recent years about the fauna of the Dark Continent—chiefly about the mammalia, but the flora and the invertebrate fauna have been more or less neglected, although they are equally remarkable and differ just as widely from those of the northern hemisphere. Mr. Synge's work will go far toward remedying that lack. The region about Uganda, of which he writes, is a strange country. Here is the home of the hyrax, that pocket-sized edition of the elephant, whose raucous ululation paralyzed the author every night until he learned what was making it; the honey plant which is merely a lobelia that has acquired the habitus of a yucca; the succulents which are not related to the cacti at all, but which have adopted the same method of fighting the relentless drought; the stone flowers, which are neither stones nor flowers. With two companions the author ascended to an altitude above which no man had ever stood before him on the slope of Mt. Ruwenzori, the snow capped peak on the equator whose glaciers feed three rivers each of continental dimensions, each seeking a separate sea, and he penetrated a forest of tree heather at an altitude of two and a half miles to look upon the silent waters of the Lake of Death, where his native porters refused to accompany him, out of fear of the unknown.

The book has been well illustrated by the brush and camera of the artist Stuart Somerville. A critic has said that the test of a painted landscape is its ability to evoke a desire to go walking in it. Judged by this criterion the illustrations pass with flying colors. The scenery of Ugan-

da is not unlike that of our own southwest, with its granite peaks and arid deserts, except that the senecios take the part of the Joshua trees and chollas, and the versatile lobelias imitate the saguaros and the biznagas.

Mr. Ratcliffe's book deals with an even stranger region—the land of the koala and the dingo, the wallaby and the platypus, the emu and the kookaburra. Although sent thither to investigate specifically the damage done by the flying foxes, which are fruit-eating dog-faced bats of considerable size (wing spreads of five feet are not unknown) and wind erosion of the soil (for Australia has a dust bowl problem even more serious than ours) he took notes on everything he saw, the jungles of tree ferns and lawyer vines and stinging trees, the eucalyptus trees of the plateaus, the evergreens of the mountains, together with their living inhabitants. He also tells us much of a personal nature about the people whom he met—the farmers, the cattle raisers, the lumber jacks, and their families breaking virgin ground for the spread of civilization—in fact, his delineations of character are on a par with his descriptions of scenery. It is difficult to imagine anyone reading this book and not wanting to go to Australia.

A Prairie Grove.

By Donald C. Peattie. Simon and Schuster, New York. $2.50. 8 x 5½; 289; 1938.

This long-range view of the early flora and fauna on the American continent approaches the proportions of an epic. The author's lyrical descriptions of the forest, the rivers, the rocks, the prairie, the grasses, the buffalo herd, the wolf and the shrew make him a master of "prose poetry." The characteristics and habits of the animals and birds in their varied and seasonal environments are described as only a keen naturalist and poet could describe them. Into this background are projected the Indian aborigines, the French explorers, priests and settlers. Later the New England pioneers are brought into the story. They were imbued with a "vision of empire" and ventured into the western wilderness that is now Illinois. The effects of the crude life and the new country upon these stalwart plainsmen and their companions are shown by drawing an idealized picture of the Goodner family. The individuals selected are perhaps symbolic of those who pioneer—their reactions and developing abilities or frailties are treated with amazing insight and understanding.

But Mr. Peattie is certainly at his best in describing the primeval prairie and the natural beauty of "the state that is shaped like an arrow-head." His esthetic appreciation of this land before "the grass at last learned obedience," and before civilization encroached upon it, is apparent in every sentence.

The book is an unusual combination. It will appeal to lovers of fine English, and will also prove a delight to those who are interested in the natural history of the Middle West. It merits many readers, and a permanent place among the classics of America. Fifteen pages of "Bibliography of Sources" at the end of the book give additional evidence of the historical and scientific data used by the author.

General Biology. *A Textbook for College Students.*

By Perry D. Strausbaugh and Bernal R. Weimer. John Wiley and Sons, New York; Chapman and Hall, London. $3.75. 9 x 5¾; xi + 555 + 13 plates; 1938.

Animal Biology. *Second Edition.*

By Lorande L. Woodruff. The Macmillan Co., New York. $3.75. 8½ x 5¾; xiv + 535; 1938.

The first volume is a new college text which presents a wealth of biological material around the general foundation of the structure-function relationship. This aspect of the book should enable students who are being initiated into the wonders of biology to gain a fuller appreciation of the functioning organism as a whole.

The authors have made a successful attempt throughout the volume to proceed from the known to the related unknown, and from the general to the more specific. The sections on the animal and

plant kingdoms are developed around the natural history of the several forms, and give special emphasis to their economic value. Rather than setting aside a few pages for the stereotyped glossary, characteristic of so many scientific books, the authors have given the etymology and meaning of new terms as they are introduced to the reader. The text is well illustrated and indexed; the latter feature affording it extra value as a general reference.

The present (second—first edition noticed in Q. R. B., Vol. 7, No. 1) edition of Woodruff's well-known college text follows very closely the content and organization of the earlier edition. Slight changes are apparent, due to recent investigation, especially in those sections which have to do with genetics. A new chapter on the "Human Background" has been added, giving a brief account of the pre-historic races of man, and their cultural development.

JOURNEY TO MANAOS.
By Earl Parker Hanson. Reynal and Hitchcock, New York. $3.00. $8\frac{3}{8}$ x $5\frac{1}{2}$; 342; 1938.

Mr. Hanson was sent to collect observations on terrestrial magnetism in equatorial South America. His book is a most interesting and enjoyable story of his experiences along the way, and something more than just an adventure story. It is filled with many penetrating observations concerning politics, economics and social changes that are occurring in the regions that he covered. The biologist will find many interesting notes on plants and animals.

I pulled in a *caribe* one night, after I had lost three hooks and had finally shown the sense to use a steel leader. It was about six inches long, with a body like that of a bass, and with an undershot jaw like a bulldog's, its mouth filled with needle-sharp teeth. As it lay gasping I pushed into its mouth a hardwood stick as thick as my forefinger. The fish bit through it with one snap. Then I could believe all the stories I had heard of *caribes* stripping the flesh from unfortunate men in ten mniutes' time, thousands of them working together, each taking its own little bite.

Concerning the jungle he says:

The truth is that one cannot talk about the Amazonian jungle as one entity. It is not a single thing. It is a composite of thousands of jungles as alike and as different as the poles of the earth, scrambled together between numberless indefinable boundaries. There can be no such rhing as one homogeneous jungle the size of the United States, and when two men argue about the nature of the Amazonian lowland forests they generally argue like blind men who have felt various parts of the elephant. Each generalizes from his own experiences in his own little part of that vast region of wild rivers and wilder forests.

BENEATH THE SURFACE. *The Cycle of River Life.*
By H. E. Towner Coston. Charles Scribner's Sons, New York; Country Life, London. $2.00. $7\frac{1}{4}$ x 5; 163 + 31 plates; 1938.

The author's many years' experience and observations in the field have made him exceptionally well qualified to write on the natural history of fresh-water life. Mr. Coston's love for nature, especially that phase of nature which has its existence beneath the surface, has not blinded him to the one fact which underlies much of his work; namely, that all activity among fish is derived from nervous reflexes and never from the process of thought.

The ecological factors influencing the cycles of life in rivers and streams throughout the year form the basis for discussion in this volume. The author presents much speculation on matters where scientific observation is difficult, but in such cases, he emphatically states that it *is* speculation and not scientific fact. The fascinating side of the study of life beneath the surface, in the words of the author, is that "we get a few facts, make a few scientific observations, then build up our knowledge on logical and ordered meditation."

The book is delightfully written, much of it in the first person, in such a manner as to make the reader feel that he has made the observations himself. The book boasts some 80 beautiful photographs, an appendix on "Cameras and nature photography," and an index.

THE ORGANIZATION OF NATURE PROTECTION IN THE VARIOUS COUNTRIES. *Special*

Publication of the American Committee for International Wild Life Protection No. 9.

By G. A. Brouwer. American Committee for International Wild Life Protection, Zoological Park, N. Y. 75 cents. 9¼ x 6; 112; 1938 (paper).

This is an English translation of the author's original Dutch publication of 1931. In the present book indices, lists and illustrations have been omitted, but an addenda of recent material is presented. The problems of geological, botanical and zoological preservation are discussed in the early pages, and then each continent is considered by countries as to methods for protection.

In Europe Germany maintains the most extensive organization for nature protection. The British are very efficient in preserving larger animal species in their African colonies, while Japan is active among the Asiatic countries. The United States and Canada keep pace with each other in protection, both being very efficient. There are a number of international congresses and organizations, most of which are devoted to some specific type of protection. A list of these is included. The one bureau which does not limit itself in this way and which deserves greater renown is the "Office international de documentation et de corrélation pour la Protection de la Nature."

THE ORIGIN OF LIFE.

By A. I. Oparin. Translation and Annotations by Sergius Morgulis. Macmillan Co., New York. $2.75. 8½ x 5½; viii + 270; 1938.

The primary assumptions are that life originated on this earth and that it neither arose spontaneously nor existed eternally, and consequently must have resulted from the evolution of matter. Starting with simple hydrocarbons, the author builds up to high molecular compounds, and as he progresses towards life by the gradual evolution of organic substances, he illustrates his assumptions by physico-chemical reactions that are known to occur. Of course there are many gaps, but the author is optimistic. "The road ahead is hard and long but without doubt it leads to the ultimate knowledge of the nature of life."

NATURE PHOTOGRAPHY AROUND THE YEAR.

By Percy A. Morris. D. Appleton-Century Co., New York. $4.00. 8½ x 5¾; xviii + 251 + 96 plates; 1938.

Each month nature reveals something new to be photographed, whether in June or December, and with each new subject a different technique has to be applied to obtain a successful photograph.

The author has hit upon a pleasant way of mixing his nature and photography. For each month he tells which plants and animals are available, what they are doing, and then how best to proceed in order to get a successful "shot." The nature lover will find his interest in photography aroused as will the photographer his interest in nature.

There are numerous illustrations some of which, unfortunately, are rather inferior.

BIOCLIMATICS. *A Science of Life and Climate Relations. U. S. Department of Agriculture. Miscellaneous Publication No. 280.*

By Andrew D. Hopkins. Government Printing Office, Washington. 35 cents. 11⅓ x 9¼ inches; iv + 188 + 1 folding chart; 1938 (paper).

This is a very comprehensive study of bioclimatics, particularly with regard to agriculture. The researches have been based on a life-time effort of the author, who has had more than a half-century of practical experience in agriculture and more than 40 years as an official entomologist. It would be surely worth while to apply the methods worked out in this study to some special problems in epidemiology and human biology.

HUMAN BIOLOGY

ON THE PROBLEMS CREATED BY THE PREMATURE SUBDIVISION OF URBAN LANDS IN SELECTED METROPOLITAN DISTRICTS IN THE STATE OF NEW YORK. *A Report to the State Planning Council of New York.*

By Philip H. Cornick. Division of State Planning, Albany. $1.00. 9 x 5¾; xxi +346; 1938 (paper).

We have all, no doubt, seen on the out-

skirts of cities real estate developments that had failed to develop and have pitied the poor suckers who had lost their money by buying lots. The thesis of this book is that the loss is spread over a much larger group than the buyers of lots. The promoter of the development usually buys the land on mortgage from the original owner and induces the local government to install water mains, sewers and street paving. The money for his sales campaign he borrows from a bank. If the rate of subdivision is no greater than the effective demand for lots, well and good. With the money which the promoter receives from the sales of lots he can pay off his mortgage to the original owner and his note to the bank and still have a profit. But promoters are a sanguine tribe. Where one has made money others hope to be equally fortunate, so that in time the supply of lots exceeds the demand. As the boom begins to ebb and prices of real estate to decline the promoter finds it harder and harder to sell his lots. The time soon comes when his indebtedness to the original owner and to the bank and the arrears on his taxes are greater than the current value of the unsold lots. He has lost what money he had put into the development. The same is true of many of the purchasers on installment contracts. Even the arrears of taxes are often greater than the current value of the land, so that neither the original owner nor the bank finds it profitable to foreclose. Both of them have lost money. Finally the high cost of foreclosure on each lot debars the municipality from taking over the land, which stands idle, while the cost of the unused improvements is borne by the other property owners of the city. Everyone loses.

How can this vicious process be prevented? In Cincinnati developers of land are required to install all necessary improvements at their own expense before the city will accept the dedication of the streets. If the developer should seek to evade such a provision by permitting the streets to remain private, the state or municipality, under its power to protect the health and safety of its inhabitants, could require, before a building permit could be issued, that proper provision be made for the supply of water and the disposal of sewage. It could, moreover, require that all deeds should state that the property fronts on a private street and that the municipality has no right or obligation to install improvements on such a street. Such measures

would take the joy out of subdividing cow pastures by saddling the costs and liabilities now borne by the general public on those who engage in such activities for profit. They would therefore impose a much needed economic check on the volume of such activities, and would tend to hold the prices—and therefore the taxable valuations—of the cow pastures down to a level at which their profitable use as cow pastures might continue.

THE STUDENT AND HIS KNOWLEDGE. *A Report to the Carnegie Foundation on the Results of the High School and College Examinations of 1928, 1930, and 1932. Bulletin Number Twenty-nine. Study of the Relations of Secondary and Higher Education in Pennsylvania.*

By William S. Learned and Ben D. Wood. With a Foreword by Walter A. Jessup. Carnegie Foundation for the Advancement of Teaching, New York. Free. 10 x 7½; xx + 406; 1938 (paper).

This study is an inventory of the knowledge of college students. In 1928 a comprehensive examination covering mathematics, the physical and natural sciences, the social sciences, literature and the fine arts was given to approximately 4,500 senior students in Pennsylvania colleges and approximately 27,000 high-school seniors. A revised test along the same lines was applied in 1930 to about 6,300 college sophomores and in 1932 to about 3,700 college seniors. For about 1,200 students results of the examination taken as high-school seniors, as college sophomores and as college seniors are available.

The most striking result is the wide range of knowledge shown by students of the same school status. In 1928 the college seniors showed a range of scores from 110 to 1580. Their coefficient of variation was 33 per cent. Yet all of these students, having spent four years at college and obtained the required number of credits, were to receive from the college the official stamp of educated men.

Although the average score of the college seniors is much higher than that of the sophomores, 28 per cent of the seniors do less well than the average sophomore and nearly 10 per cent do less well than the average high-school senior. So also the average high-school senior score is below the average college sophomore level but 22 per cent of this secondary-school group surpass it and 10 per cent exceed the college-senior average. In other words, students classified as sophomores range, as to their command of knowledge appropriate to their status, from a general level of inferior high-school achievement to one attained only by the best 10 per cent of senior college students—indeed, above the average of faculty groups.

A disquieting result is the low rank of students of education. The median score of such students in arts colleges was well below the general median and the median score of students in teachers colleges was still lower. In these colleges the median for sophomore students of education was actually below that of the high-school seniors. The prospective teacher knew less than the students he (or she) was expected to teach.

TRANSACTIONS OF THE AMERICAN PHILOSOPHICAL SOCIETY HELD AT PHILADELPHIA. *New Series*, Volume XXIX, Part II. Article II, *The Variation in the Silicate Content of the Water in Monterey Bay, California, During 1932, 1933 and 1934*, by Austin Phelps; Article III, *The Old Stone Age in European Russia*, by Eugene A. Golomshtok.

University of Pennsylvania Press, Philadelphia. $3.00. 11¾ x 9¼; 153–468 + 37 plates; 1938 (paper).

This issue of the Transactions of the American Philosophical Society consists of two articles, the first of which is a discussion of the silicate content of Monterey Bay by Austin Phelps, in which the silicate concentration is shown to be a function of the depth and temperature. The second article deals with palaeolithic man in European Russia, and is by Eugene A. Golomshtok.

Russia occupies a critical position in anthropology and archaeology, because while it is pretty generally accepted that man originated in south east Asia, practically all the information we have about palaeolithic man has come from finds in western Europe, and it is difficult to see how he could have arrived there without crossing Russia. Yet until recently no one has thought seriously of searching that country for fossils or artifacts.

The greater part of the present work is a highly technical discussion of material from fifty-five different sites in European Russia, with excellent photographic and hand-made illustrations. But the interpretation of these finds is attended by a great deal of difficulty, as there is wide divergence of opinion among Russian authorities as to the correlation of the horizons in which they occurred with the type horizons in France. The latter are cultural horizons and represent successive stages in development; the two species and various subspecies of man may have passed through corresponding stages at different periods, so that contemporary cultures in separated geographic localities are not necessarily homologous; indeed the contrary is generally the case. The two most primitive cultural horizons in France, the Chellean and the Acheulean, have not as yet been detected in Russia (with the exception of one find of doubtful authenticity) and even geologists disagree as to how many glaciations there have been in that country, and how they correlate with the four advances of the ice that have been recognized in Western Europe and North America.

The author does not draw any conclusions of his own, but states those of most of his contemporaries, discussing with all fairness, both the facts that seem to support them and those that militate against them. The bibliography covers seven pages and the index eight.

THE APACHE INDIANS.

By Frank C. Lockwood. The Macmillan Company, New York. $3.50. 8½ x 5⅝; xvi + 348 + 42 plates; 1938.

In essence this book is a well-written account of the struggle between the Apache Indians and the United States government, with the latter, sad to note,

not shining very brightly either in the manner of conducting the conquest or in that of abiding by its treaties. With deep sympathy for the Apache, the author briefly outlines what is known about the origin of these peoples, their culture, social system and their savagery which was to engender a healthy fear in both the Spanish and the Mexicans. The earliest recorded account of a clash between the Apache and Americans took place in 1825 but a friendly understanding was reached and maintained for 10 years. In 1835 hostilities recommenced, the whites being apparently at fault, and continued off and on until 1886. At this date the last group of Apache, 36 in all, including 19 women and children, voluntarily gave themselves up to 5000 soldiers who had been after them for over 4 months. As it had before, the government again broke its promises and instead of allowing the Apache to return to the original reservations given them, imprisoned them all, friendly and hostile Indians alike, for four years. In 1890 the survivors were finally allowed to return to the reservations where their descendants now live. To a varying degree the Apache have adapted themselves to the white man's way of living. They have apparently not suffered from the contact with the white man, since in 1936 they numbered about 7500, which is nearly 1500 more than in 1886. In general, the author finds them industrious and very able in certain types of work, but in moral matters, according to Christian views, they have progressed very little and in this respect the author holds little hope for the future. This book, besides its literary and historical value, presents a number of interesting features for the human biologist. Not the least is the contrast between that period in the nation's history and the immediate present characterized by loud proclamations regarding the sanctity of treaties and the official verbal excoriation of aggressor nations.

ISAAC NEWTON, 1642–1727.
By J. W. N. Sullivan. With a Memoir of the Author by Charles Singer. The Macmillan Co., New York. $2.50. 8½ x 5¾; xx + 275; 1938.

This book is, we regret to say, the last work of one of the ablest interpreters of science to the public. In the introductory memoir of Sullivan Singer writes: "In describing his mental characteristics the phrases that seem to me best to recall his special qualities are 'intellectual integrity' and 'capacity to penetrate to the essential nature of a problem.' "

In his prefatory note Sullivan writes: "I have long been impressed by the fact that Isaac Newton, besides being the greatest of scientific geniuses, was also one of the most singular and fascinating characters of which we have any record." The puzzling question to which Sullivan directs his analysis is this: Why did Newton let his unique combination of gifts as a mathematician and as an experimentalist lie fallow for so much of his life? After the period in his twenties in which he made his fundamental discoveries on the composition and refraction of light and laid at least the foundations of the differential calculus and the theory of gravitation Newton's interest in scientific work steadily declined until it was rekindled by Halley. And after the seventeen months of intensive work that produced the *Principia* he spent the remaining forty years of his life in work on theology and chronology and in his official duties as Master of the Mint with only occasional attention to scientific problems. Why was this? Sullivan's answer is that Newton felt that science was relatively unimportant. "Newton genuinely believed that man was part of a Divine Scheme, and that the material universe was no more than the setting within which part of his eternal destiny was to be worked out. . . . The paradox of Newton's scientific career is due to the fact, probably unique in the history of scientific men, that he was a genius of the first order at something he did not consider to be of the first importance."

CIVILIZATION AND DISEASE.
By C. P. Donnison. With an Introduction by Sir Walter Langdon-Brown. William

Wood and Co., Baltimore. $3.00. 8½ x 5¼; xv + 222; 1938.

Taking as a point of departure the stated fact that among the peoples of the Western civilization, when compared to other ethnic groups, there is a higher incidence of hyperpeisia, Grave's disease, peptic ulcer and diabetes, the author discusses the probable factors related to this difference. He summarizes the information about the possible etiological causes and is led to believe that a psychogenic factor associated with civilization is responsible for the relative prevalence of the above diseases among the white peoples. The greater part of the book is taken up with an inquiry regarding this factor. The author examines critically the theories of Freud and his school, of McDougall and others and finally concludes that the psychic factor arises from a conflict due to the lack of proper social integration. In other words, while the savage from the earliest period of his life is in contact with the remainder of his social group, the civilized youngster is not and must readjust himself after his behavior has already been conditioned by the selected small group which surrounds him. An unsatisfactory readjustment will therefore lead to a psychic imbalance. There is much to be said for such a theory which leans strongly towards Adler's ideas. It deserves consideration even though, as the author notes, the data purported to show the differences in disease incidence between the savage and the civilized are far from satisfactory, and much has yet to be learned about psychic factors in the causation of organic diseases.

La Population de la France. *Son Évolution et ses Perspectives.*

By Michel Huber, Henri Bunle and Fernand Boverat. Preface by A. Landry. Librairie Hachette, Paris. 30 francs. 8½ x 5½; xiii + 250; 1937 (paper).

The first two parts of this book, ably prepared by Huber and Bunle, constitute a complete summary of the demographic conditions of France at present and in the past, and include comparable data regarding other European countries, particularly Germany. The facts presented are well known: (1) the French population is practically stationary and most of the recent slight increase is due to immigration, (2) the birth and death rates continue to decrease but the latter is still relatively high. The prospects for the future of the French population are therefore exceedingly dark according to Boverat who discusses these observations. In contrast to some students who believe that a stationary or declining population is a blessing, Boverat belongs to that school that sees in such a trend the downfall of a nation, because industry and agriculture are adversely affected and due to their interdependence both will eventually fail. To remedy this situation which seems to him very serious he calls, as is usual, for government aid. First of all, he desires more stringent laws against abortions. Secondly he proposes a campaign of education in the schools so that children will learn early that large families are needed. An appeal is to be made to their patriotism and if this fails monetary incentives should be tried. In view of the marked lack of success which has followed such plans in the past in France as well as in other countries, it is doubtful whether this one, should it be followed, will alter appreciably the situation.

The Human Organism and the World of Life. *A Survey in Biological Science.*

By Clarence W. Young, G. Ledyard Stebbins, and Clarence J. Hylander. Harper and Brothers, New York. $3.00. 8½ x 5½; viii + 657; 1938.

This work differs from most other biological treatises chiefly in its method of approach. Instead of contemplating the science from the aesthetic standpoint of the seeker who pursues truth for its own sake without regard to where it may lead him, the authors have chosen to approach from the cultural or practical standpoint. They are not interested in inspiring the student to undertake original work so much as to awaken in him an appreciation of what others are doing, that he may understand how those in contact with him react to and interpret their common en-

vironment. Further, the field of biological research includes man himself. The Socratic philosophy was based upon the dictum "Know thyself," and a greater teacher than Socrates is reported to have said "The kingdom of God is within you, and he that knoweth himself shall find it." It is no longer fashionable to speak of the body as the environment of the soul, but the fact remains that man is a conscious being in possession of a physical body from which he cannot be separated during his life, and it is therefore obvious that a knowledge of how the body came to be, how it functions, and how it should be cared for is an essential component of a liberal education. The authors have produced a readily readable book covering these matters which is addressed not to the specialist but to the average reader, and which deserves wide recognition. The sections dealing with endocrinology and psychiatry are especially timely. The index covers 18 pages.

RUSSIAN MEDICINE. *Clio Medica.*
By W. Horsley Gantt. Paul B. Hoeber, Inc., New York. $2.50. 6½ x 4½; xiii + 214; 1937.

In an interesting and scholarly manner Gantt traces the trend of medical practice and teaching in Russia from its very early primitive form to the much publicized present day system. Western physicians were first introduced in Russia about the beginning of the 15th century but, as for all arts and sciences, it was not until Peter the Great, himself a student of medicine, began the attempt to reorganize Russian society along Western lines that hospitals were established and trained physicians began to replace faith-healers, bone-setters and other unorthodox practitioners of the art of medicine. By the end of the 19th century, although the standards of medical training in Russia were inferior to those of the occidental world, already biologists such as Von Baer had been produced, and surgery had its Pirogov, physiology its Sechenov, Mechnikov and of course Pavlov. In addition, the first serious attempt towards the creation of a socialized system of medicine had already been made with the organization, *ca.* 1870, of the Zemstevo, the direct ancestor of the Soviet system. Regarding the latter, Gantt has a great deal of praise not unmixed with skepticism. He has personally observed the immense progress in public health made during the Soviet regime, but like all unbiassed observers he questions whether this progress is due to communism *per se*. The book is well indexed, and contains a short but adequate bibliography and a table of comparative chronology of medical events in Russia and in the remaining world.

LES CRISES DE LA MORALE ET DE LA MORALITÉ *dans l'Histoire de la Civilization et de la Littérature des Pays Anglo-Saxons.*
By Paul Yvon. Boivin et Cie, Paris. 20 francs. 9 x 5½; 127; 1937 (paper).

The French, Yvon notes, picture the typical Englishman as a strait-laced sourpuss. This view is apparently justified by the almost universal tendency on the part of English as well as American writers to preach a sermon on morals. Since literature, to a certain degree, mirrors the mores of a given country and period, the author investigates the mode of development of this moralistic tendency in the English literature of 1660 to 1820 and describes the social factors associated with it. He distinguishes three periods: 1660–1710, 1710–1760 and 1760–1820. The first period, characterized by the writings of Wycherley, Behn and Dryden, manifests clearly the overt libertinage of the aristocrats of the Restoration. In the second period, the Stuarts having been superseded and the middle class having attained a share of the power in government, the literature is realistic but the moral conventions are no longer so openly flouted. In this period we find Addison, Steele and Sterne. Between 1760 and 1820, with the rise in power of the middle class and the conservative reaction to the French revolution, the tendency to moralize becomes more marked and is finally transformed into the Victorian rigorism and artificiality. As conducted here, this analysis is rather superficial and not very informative. It does, however, demonstrate the

benefits of utilizing another source, literature, in the study of social phenomena.

EARLY SCIENCE IN OXFORD. *Vol. XI. Oxford Colleges and Their Men of Science.*

By R. T. Gunther. R. T. Gunther, Old Ashmolean Building, Oxford. £1.10. 8¼ x 5¼; xvi + 429 + folding chart; 1937.

The latest volume of Dr. Gunther's series gives brief biographic notes on Oxford scientists, arranged by colleges. These range in time from John of Gaddesden, of Merton College, the author of the *Rosa medicinae* who graduated M.D. about 1309, to the twentieth century. Among the names of greatest interest to a biologist are Harvey, Baillie, Cunningham, Lyell, Ray Lankester, Gilbert White, Pennant, Bather, G. S. Haldane, Linacre, Sydenham, Wren, Mayow, Burdon-Sanderson, Willis, Lower, Hooke, Osler, Highmore, Wharton, Poulton, Tyson and Rolleston. "In 1845, Dr. Gunther writes, "the attitude of Oxford to science was not so much hostile as contemptuous. It is true that the existence of science was asserted by thirteen salaried professors, a Museum, A Physick Garden, and an Anatomy School; but the professors did not lecture: the Museum contained little beyond a verminous giraffe, a lode-stone, a mummy, King Alfred's jewel, and a fine twelfth-century Bestiary which was shown to visitors who could pay sixpence." If Oxford is now more hospitable to science, there is evidence in this book that the history of science is still a Little Orphan Annie.

THE HYGIENE OF HOUSING. *Report by the Housing Commission. League of Nations, Bulletin of the Health Organization, Vol. IV, No. 4, August 1937.*

Edited by the Health Section of the League of Nations, Geneva. Publications Department of the League of Nations, Geneva; Columbia University Press, New York. 65 cents. 9½ x 6; 505–682; 1937 (paper).

This number of the Bulletin contains two articles. The first is a report by the Housing Commission on the subject of the hygiene of housing. In this report, a first part discusses the scope and organization of the commission; in the second part are presented the results of a very general survey of expert opinion on the methods of heating and cooling houses in France, England and the United States. The report concludes with a plea for more data and international cooperation.

The second article is a review by Wroczynski of studies on physical development and physical defects in children. The author considers, in particular, certain methods of physical measurements, the physiologic changes accompanying exercise and the types of physical education used in several countries. The main conclusion reached is that notwithstanding the importance given at present to physical education the prevalence of physical defects has not been reduced. This study is characterized by superficiality and an inadequate bibliography, especially that referring to investigations made in this country.

CLAUDE BERNARD *Physiologist.*

By J. M. D. Olmsted. Harper and Brothers, New York and London. $4.00. 8½ x 5½; xvi + 272; 1938.

It is unexplicable why so few biographies of Claude Bernard have been published; this is the first English book-length study which has appeared since 1899. Yet not only were Bernard's achievements remarkable but his whole philosophical attitude towards research was unique and deserves to be meditated upon by all students of science. In addition his personal life was not devoid of human interest. He came of peasant stock, received a somewhat mediocre secondary education and entered the Paris medical school at the age of twenty-one. For a year and a half before that he had been a pharmacist's apprentice and had unsuccessfully attempted to become a playwright. Even after he entered medical school Claude Bernard found himself only after he came under the influence of Magendie. The latter impressed his views and methods on the brilliant assistant and aided his advancement. The details

of Bernard's career, the significance of his work, his marital unhappiness are all fully given in this book. Written with admiration and understanding of the man and the scientist this biography is a real contribution to the history of biology.

ARCHITECTS OF IDEAS. *The Story of the Great Theories of Mankind.*

By Ernest R. Trattner. Carrick and Evans, New York. $3.75. 9¼ x 6⅛; [8] + 426 + 15 portraits; 1938.

In chronological order, beginning with Copernicus and ending with Einstein the author outlines the biography and scientific contributions of 15 men whose ideas are considered to be the foundation of modern science. A chapter is dedicated to each of them and each chapter includes a brief discussion of the predecessors and followers of the principal character as well as a consideration of the import and consequences of the theory he advanced. The "architects" include Copernicus, Hutton, Dalton, Lavoisier, Rumford, Huygens, Malthus, Schwann, Darwin, Marx, Pasteur, Freud, Chamberlin, Boas and Einstein. Naturally, any such list is always open to criticism and this one seems particularly vulnerable. Aside from this, the book is a satisfactory source of information about some of the main developments in the history of science. It is written in a pleasing style bordering on the journalistic. A few times the lightness of touch and economy of language is carried too far and the following results: "For many years she (Pasteur's wife) was to bear him children and hold his meals hot while he stayed overtime in his laboratory."

URBAN SOCIOLOGY.

By Earl E. Muntz. The Macmillan Co., New York. $3.75. 9¼ x 6¼; xvi + 742; 1938.

This text attempts to cover, and does so rather successfully, the various aspects of urban development in the United States. In the first part there is a brief historical account of urbanism and chapters on the growth of modern cities especially those of the United States, problems of rural and foreign migration, and city planning. The second part concerns housing, its progress in recent years and the development of suburban areas. In the third part the author discusses public health, sanitation and safety as achieved in urban areas: the problem of water supply, garbage, hospitals and medical and school care. Education is the topic of the fourth part which describes the development of public, vocational and special schools. The fifth part deals with recreation, public and private amusement centers. The presentation of the subject is historico-descriptive and factual without any attempt to theorize on the past or to predict the future. Interesting data are included and there is an adequate bibliography.

SINGING FOR POWER. *The Song Magic of the Papago Indians of Southern Arizona.*

By Ruth M. Underhill. University of California Press, Berkeley. $2.00. 8½ x 5½; vii + 158; 1938.

The author spent 14 months in the Papago country of southwestern Arizona studying the everyday life and activities of this quiet race, and in this little volume she has recorded much of their folk-lore and customs, as well as the translation of many of their magic songs. The underlying foundation of the Papago Indian life, and the source from which they derive their deepest thought and power is the magic of song. Whether they be working, playing, worshipping, harvesting, or making war, these Indians find expression for their innermost feelings in the form of song.

The book is interestingly written in a style (first person and present tense) which makes delightful reading for both those keenly interested in Indian folk-lore, and those interested in the varied and subtle forms of human nature.

CRIME, CROOKS AND COPS.

By August Vollmer and Alfred E. Parker. Funk and Wagnalls Co., New York. 2.00. 7½ x 5; v + 260; 1937.

The authors, in writing this little book,

have made an exceptional appeal to two groups of people: (1) those who delight in mystery and crime detection stories, and (2) those who are convinced that anything but justice comes from our present court and prison systems.

The first part of the book deals with numerous "baffling cases" in the history of crime detection, and gives some idea of how science is being used and must be more and more used in solving crimes which are planned by master minds, and which approach perfection. The latter portion of the volume deals strongly and bluntly with the inefficiency of our court systems; with the incongruity of mixing politics with law and expecting to get justice; and with the deplorable status of our prisons and reform schools. Throughout the volume there is an appeal to incorporate into our social system better trained police officers, attorneys, judges, and prison personnel.

DIE AKKLIMATISATION. *Eine Untersuchung über ihre Bedingungen, ihre Fehlschläge und ihre erfolgreiche Führung.*

By J. Grober. Gustav Fischer, Jena. RM. 6.50 (paper); RM. 8.00 (bound). 10¼ x 6¾; 156; 1936.

Although written by a professor of medicine this book is not intended for medical men alone, but also for merchants, political economists, soldiers, and especially for statesmen. Its purpose is to serve the expansion of nations in the settlement of the earth's area and the welfare of the settlers. To this end the author has emphasized the mistakes made in the colonization programs of the past. Material on the introduction of new crops and animals into a region and the conversion of waste-land into profitable areas is discussed to some extent but the main portion of the book is devoted to the acclimatization of man, especially of the white race, to various environments. The effects of changes of climate are discussed not only relative to the generation that has migrated either as adults or in childhood, but also in respect of the children born in the adopted clime. The treatment of the subject is general but the book should nevertheless be useful to anyone interested in population problems. There is a short list of authors cited and an index.

AFRICA'S GOD. *VIII. Rhodesia. Anthropological Series of the Boston College Graduate School, Vol. III, No. 1.*

By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass. $1.00. 9¾ x 6¾; 37; 1938 (paper).

The eighth report on the religion of Africa is concerned with Rhodesia, where, as in other parts of Africa previously reviewed, monotheism prevails. Although some tribes, such as the ba-Tonga, are found to be strictly monotheistic, others show but obscure and vestigial tendencies towards monotheism. The question of possible diffusion, especially Hebraic, or of independent origin of the monotheistic culture is considered, as in former reports. In addition to interesting, but highly speculative, theories on linguistic derivations, various tribal laws, customs, proverbs, and legends are included.

In view of the irreparable losses engendered by past faulty records in archaeological field work, there is an additional article by J. W. Murphy, *S.J.*, who presents a brief survey of the careful procedure of prehistoric excavations at Ksar 'Akil.

YUKON VOYAGE. *Unofficial Log of the Steamer Yukoner.*

By Walter R. Curtin. Caxton Printers, Caldwell, Idaho. $3.50. 9 x 6; 299 + 56 plates; 1938.

For lively and unadulterated adventure, "Yukon Voyage" is hard to beat. The volume presents in dramatic fashion, the unofficial log of the steamer "Yukoner" on her gold rush voyage from St. Michael to Dawson in the years 1898–99. For many of the individuals aboard the marooned ship, the eight months spent in almost complete isolation seemed a dreary and unbearable eternity, but for Walter Curtin it was, in his own words, "the most enjoyable vacation I ever had." Mr. Curtin's observations and his reactions to his surroundings were clearly set

down in an orderly, yet subtly humorous fashion in his diary. The majority of this work is taken directly from the pages of the diary. The work is well illustrated throughout by drawings and photographs. As a result of the interest in human nature, and the display of pure adventure, the book will undoubtedly be a source of absorbing enjoyment to many of its readers.

MIDDLE AGE IS WHAT YOU MAKE IT.

By Boris Sokoloff. The Greystone Press, New York. $1.75. $7\frac{3}{4}$ x $5\frac{1}{2}$; xv + 204; 1938.

The author of this interesting little volume was a student of Metchnikoff, and in consequence he incorporates into his text much of the Metchnikoff school of thought. The book is not intended so much for the specialist of the medical profession, or even the general scientist, as it is for the man of the street. It is written in a popular style, and contains much encouragement for the man of forty who is convinced he is growing old. Dr. Sokoloff emphasizes the need for the layman to learn something of his own normal physiological processes, and to be guided by a competent physician in his search for health and happiness during middle age, instead of by the high pressure patent medicine advertisements.

BARON CONSTANTIN VON ECONOMO. *His Life and Work.*

By his wife and by J. von Wagner-Jauregg. Translated from the second German edition by Ramsay Spillman. (Obtainable from the Translator, 115 East 61 St., New York). $2.00. $9\frac{1}{2}$ x $6\frac{3}{8}$; x + 126; 1937.

This is a fascinating biography of the famous investigator of cerebral histology and discoverer of encephalitis lethargica, who was a pioneer aviator, flying his own plane as early as 1908. The biography of Economo, who died in 1931 at the age of 55, is written by his devoted wife. The psychiatrist von Wagner-Jauregg, Vienna clinician and teacher of Economo, adds a brief survey of his scientific work. The English text is further augmented by the three papers which Economo read in New York in 1929—Sleep as a problem of localization; Some new methods for studying brains of exceptional people; Cytoarchitectony and progressive cerebration. The translator is right in regarding this biography as a great human document.

A HANDBOOK OF METHODS FOR THE STUDY OF ADOLESCENT CHILDREN. *Monographs of the Society for Research in Child Development. Volume III, No. 2 (Serial No. 15).*

By William W. Greulich, Harry G. Day, Sander E. Lachman, John B. Wolfe, and Frank K. Shuttleworth. Society for Research in Child Development, National Research Council, Washington, D. C. $2.25. 9 x 6; xvii + 406; 1938 (paper).

This monograph was prepared as a methodological aid for the study of child development. The material is presented in five parts: I. Some anatomical aspects, II. Some biochemical and physiological aspects, III. Respiration and energy metabolism, IV. Some psychological aspects, V. Problems not involving direct measurements of children. The subject matter of each part consists of concise formulations of methods available for investigating problems relating to child development. Essential known facts with regard to each problem are stated briefly, and the basic literature is listed at the conclusion of each separate discussion. A tremendous mass of material is made readily available through this handbook which should be invaluable to investigators in all fields of child development.

AN INTRODUCTION TO PHYSICAL ANTHROPOLOGY.

By E. P. Stibbe. With an Appendix by W. A. M. Smart. Edward Arnold and Co., London; Longmans, Green and Co., New York. $3.25. $8\frac{3}{8}$ x $5\frac{1}{4}$; vii + 230; 1938.

This edition (first reviewed in Q. R. B. Vol. 6, p. 361) shows considerable revision. A. H. Munter has assisted in some of the text work, Le Gros Clark has been consulted on a number of points concerning the primates, and W. A. M. Smart

contributes a short appendix on the statistical examination of anthropometric data. The general treatment of the material is simple and clear enough to give an excellent introduction into methods and problems of physical anthropology. Figures, a glossary of technical terms, and a well-arranged index are included in the volume.

FEARFULLY AND WONDERFULLY MADE. *The Human Organism in the Light of Modern Science.*

By Renée von Eulenburg-Wiener. The Macmillan Co., New York. $3.50. 9¼ x 6¼; xii + 472; 1938.

The book deals with the functions of human organism, its physiology, anatomy and behavior as a whole. Its point of view is philosophical as well as biochemical and bio-physical. The author has found it necessary to enlarge upon the physico-chemical laws and especially to inquire into the significance of the asymmetric structure of the bio-molecules for the phenomena of life. The great Pasteur recognized that this asymmetry was the one distinct line of demarcation between the organic and inorganic world, as the writer notes in her thoughtful introduction.

THE BANTU TRIBES OF SOUTH AFRICA. *Reproductions of Photographic Studies. Vol. III, Section III, Plates LXXXI–CXX. The Nguni. Section III, The Zulu. With an Introductory Article on the Zulu, a Bibliography, and Descriptive Notes on the Plates by D. McK. Malcolm.*

By A. M. Duggan-Cronin. Deighton, Bell and Co., Cambridge. 25s. net. 11¾ x 8¼; [8] + 16 + 40 plates; 1938 (paper).

This volume, which represents a small portion of the entire study of the Bantu tribes of South Africa, concerns itself with the Zulu only. A brief note dealing with the geneology and social customs of the tribe is presented, together with an extensive bibliography of studies of South African tribes in general. The greater portion of the volume is devoted to pictorial studies of the dress, homes, customs, activities and environment of the Zulu.

ZOÖLOGY

BIRD FLOCKS AND THE BREEDING CYCLE. *A Contribution to the Study of Avian Sociality.*

By F. Fraser Darling. The University Press, Cambridge; The Macmillan Co., New York. $1.75. 7½ x 5¼; x + 124; 1938.

The author, with his wife, spent almost two years on Priest Island, a small uninhabited island off the North West Highlands, observing the social behavior of various species of sea-birds. From blinds in different parts of the island he could make almost continuous observations on five colonies of gulls through their entire breeding cycles. From these studies, he concluded that successful breeding, mating, and care of the young depends largely on communal life.

The book contains a summary of recent discoveries in the field of endocrinology which, he believes, might help to explain the cyclical behavior of these flocks of birds. His interest lies particularly in glandular alterations produced by external stimuli such as changes in light, temperature, and social contacts.

Fraser Darling appears to have something less than wholly adequate power to present his own highly important results in the most effective way. The distinction of his work lies in its *insight*, unsurpassed in the domain of behavior research under natural, field conditions. This brief notice may well conclude with an illuminating quotation.

> The brain of the bird does not have the cerebral cortex which distinguishes the mammalian brain. If conjecture were to be made on the possible further evolution of avian behaviour, it would probably be suggested that the bird is moving along the line of perfection of instinctive behaviour rather than following that of an increasing tendency towards grasping new situations and wholes, and making ready adaptations which are characteristic of the development of mammalian behaviour. Do not let me be thought to say that the bird we know is incapable of adaptive behaviour, for it would be easy to point to many remarkable examples; but what appears to us as a very complicated pattern may be found to be explicable on a few key reactions.

When considering the manifold effects of the mate or companion on the life of the individual bird, it is well to remember how improbable it is that the individual can have any clear realization of self. It cannot say to itself, *Cogito, ergo sum.* And I think this lack may impose the necessity of a companion or mate to supply visual and auditory stimulation in order to live more or less fully. This need, expressed in many ways, may be supplied by the one mate or more than one in birds of different social thresholds. One action calls forth another from the mate or companion and that in turn may lead the first bird to a third pattern. A chain of distinctive behaviour is elicited by this reciprocation.

THE LIFE STORY OF THE FISH.

By Brian Curtis. Introduction by William Beebe. D. Appleton-Century Co., New York and London. $3.00. $8\frac{1}{8}$ x $5\frac{5}{8}$; xiv + 260; 1938.

There is nothing dry about this fish story. The author succeeds amazingly well in achieving his expressed intention of giving "a general understanding of why fish behave as they do." A fund of scientifically accurate information on fossil as well as recent fish, is given by Mr. Curtis in a most lively and entertaining style. His sense of humor is as keen as his power of observation and he has consummate skill in transmitting his knowledge and eager enthusiasm to his readers.

Even if heretofore the reader's knowledge of a fish has been confined to specimens caught with a can-opener, after reading this book, interest in the whole fish, its structure, characteristics, behavior and habitats will be increased a hundred fold. As William Beebe aptly says in his introduction to the book, "as you read it, you learn and laugh, and learn again." The physiological relationship between fish and man is most engagingly set forth, and Mr. Curtis answers many questions that pertain to the entire field of biology. The amateur fish-fancier with an aquarium in the window, the fisherman, and sportsman who wants to know more about fish in general, or game fish in particular, as well as the student of ichthyology or biology will each find just the information he desires.

Excellent diagrams, plates and charts fully illustrate the text, and there is an adequate index of six pages.

INDEX-CATALOGUE OF MEDICAL AND VETERINARY ZOÖLOGY. *Part 1. Authors: AALL to AZZOLINA. U. S. Department of Agriculture.*

By Albert Hassall and Margie Potter. Government Printing Office, Washington. 10 cents. $\frac{1}{4}$ x 6; 142; 1932 (paper).

INDEX-CATALOGUE OF MEDICAL AND VETERINARY ZOÖLOGY. *Part 2. Authors: B to BYCHKOV. U. S. Department of Agriculture.*

By Albert Hassall, Margie Potter, Mildred A. Doss, Marion M. Farr and Gertrude B. Carson. Government Printing Office, Washington. 55 cents. $9\frac{1}{4}$ x 6; 143–612; 1937 (paper).

The U. S. Department of Agriculture is now issuing a revised and enlarged edition of the *Index-Catalogue of Medical and Veterinary Zoölogy—Authors* (first published in 1902–1912). This is a most valuable addition to any biological library and since it will be some time before all the parts are out it behooves those who possess the early numbers to see that a special place is reserved for the addition of future numbers and to obtain them. The various parts of the catalogue are no longer being published under the joint authorship of Stiles, Hassall, *et al.* Dr. Stiles is continuing the publication of the host catalogue from the National Institute of Health, and Hassall, Potter *et al.* have taken over the separate publication of the author catalogue. Each part of the author catalogue has sections on abbreviations for single words, for libraries, and a key to serial abbreviations, all of which precede the index section.

ОБШАЯ ЗООГЕОГРАФИЯ

В. Г. Гептнер. Государственное Издательство Биолотической и Медицинской Литературы. Москва-Ленинград. 548; 13 рубл. 60 коп.; 1936.

[GENERAL ZOÖGEOGRAPHY.

By V. G. Heptner. State Publishing House for Biological and Medical Literature, Moscow and Leningrad. 13.60 roubles. 548; 1936.]

This important book is written by a zoölogist who has a wide travelling experience in various parts of U.S.S.R. and attempts

to give a harmonious union of both ecological and historical viewpoints in explanation of the present day distribution of animals. There are four parts: (1) Introduction, (2) The conditions of existence of animals and their geographic distribution, (3) Animal dispersal and area, (4) Comparative zoögeography. A special chapter on bird distribution is written by Dr. Dementieff, an ornithologist at the Zoölogical Museum of the Moscow University. This book is worthy of every attention of field and museum naturalists in America. Numerous illustrations may be useful to those who are not familiar with the Russian language.

THE BLUE-WINGED TEAL. *Its Ecology and Management.*

By Logan J. Bennett. Collegiate Press, Ames, Iowa. $1.50. 9 x 6; xiv + 144; 1938.

This thesis is a carefully planned and well organized study of the natural history of the Blue-winged Teal (*Querquedula discors* L.). The author deserves much credit for his persistent and keen field observation, and for his critical evaluation of the data. A thorough description of the bird's characteristics, breeding range, migration, nesting and food habits, as well as proposed methods for its conservation form the body of the text. The volume contains many tables, charts and maps relating to the subject, as well as many carefully selected photographs. An extensive bibliography and an index add considerably to the value of this fine work.

HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung 471. Abt. IX, Methoden der Erforschung der Leistungen des tierischen Organismus, Teil 6, Heft 4 (Schluss). Methoden der Meerwasserbiologie.* Containing the following articles: ***Narkose und Anästhesie wirbelloser Tiere des Süss- und Meerwassers***, by Carl I. Cori; ***Allgemeine Gesichtspunkte für die Einrichtung biologischer, hydrographischer Meeresanstalten und Fischereistationen***, by Carl I. Cori, Thilo Krumbach, and Hjalmar Broch.

Urban and Schwarzenberg, Berlin. RM. 9.50; (25 per cent reduction outside of Germany). 10 x 7; 135; 1938 (paper).

The first article contained in the number lists (a) various anesthetics together with their properties and their adequacy in work with invertebrate marine and fresh water animal forms, and (b) these organisms with the work which has been done upon them to show the effects of anesthetics or narcotics.

The second paper is a very detailed exposition of the structure and arrangement of marine and fishery stations as they should be and as they are.

LAC CULTIVATION IN INDIA. *Being a Second and revised edition of "A Practical Manual of Lac Cultivation" by P. M. Glover, Published in June 1931.*

By P. M. Glover. Indian Lac Research Institute, Namkum, Ranchi, Bihar, India. Rs. 2. 9¾ x 7½; [8] + 147 + 16 plates; 1937.

This volume is a manual on the methods of lac cultivation, with its attendant problems of lac hosts, the inoculation and propagation of the lac insect, parasites and predators, the manufacture of shellac, etc. The principle value of the book will be for those concerned with the lac industry; it will also serve as a reference on the subject. It includes plates and figures, appendices and a bibliography.

ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIII, Part 1, Numbers 1–4.*

New York Zoological Society, Zoological Park, New York. $1.25. 10½ x 7; 98 + 18 plates; 1938 (paper).

This number of *Zoologica* contains papers on the following subjects: (1) The significance of differential locomotor activity as an index to the mass physiology of fishes; (2) A study of the anoplocephaline cestodes of North American rabbits; (3) Penaeidae from the region of Lower California and Clarion Island, with descriptions of four new species (Templeton Crocker Expedition), and (4) Fibro-epi-

thelial growths of the skin in large marine turtles *Chelonia mydas* (Linnaeus).

DIE STAATEN DER AMEISEN.

By Wilhelm Goetsch. Julius Springer, Berlin. 4.80 gold marks. $7\frac{1}{4}$ x $4\frac{1}{2}$; vii + 159; 1937.

A popular book on the wonder world of the ants, and the development of their social life. It appears in the collection *Verständliche Wissenschaft*. The author utilizes many of his own observations made in different countries of the world. A series of simple but excellent illustrations (84 in number) occur in the text but no index has been prepared.

BIENENGIFT ALS HEILMITTEL.

By Robert Schwab. Georg Thieme Verlag, Leipzig. M. 2.40. $9\frac{5}{8}$ x $6\frac{3}{8}$; 48; 1938 (paper).

In this booklet bee poison is recommended in the treatment of rheumatic diseases. There are different preparations now in trade for injection as well as for embrocation. No attempt has been made by the author to prove the efficacy of this treatment by dealing with exact histories of patients or therapeutic statistics.

BOTANY

GENERAL PLANT PHYSIOLOGY.

By E. C. Barton Wright. Foreword by Sir F. Gowland Hopkins. Williams and Norgate, London. 15s. net. $8\frac{1}{2}$ x $5\frac{5}{8}$; 539; 1937.

AN INTRODUCTION TO THE PRINCIPLES OF PLANT PHYSIOLOGY.

By Walter Stiles. Methuen and Co., London. 27s. 6d. net. $9\frac{3}{4}$ x $6\frac{1}{4}$; viii + 615; 1938.

Both of these texts will be found most useful. Their authors are Englishmen—Wright, formerly Lecturer in Botany in King's College, London, is now a biochemist to the Research Association of British Flour Millers; Stiles is Mason Professor of Botany in the University of Birmingham. The first of the volumes (forward by Sir F. Gowland Hopkins O.M.)

is meant as a general survey of plant physiology for first and second year University students. It does not pretend to give the most recent information on any one particular branch; rather has the aim been to discuss the fundamental principles of the subject. A large number of different texts have been consulted and references to the literature from 1900 onwards are given on each page.

There is an appendix on "The conception of pH," a general bibliography of 87 references, and author and subject indexes. The second volume (begun ten years ago and first printed in 1936) was written especially for "University students reading for pass or honours degrees." No attempt has been made to mention all the important researches in plant physiology—only those have been referred to that are useful in emphasizing the fundamental principles. "Purely biochemical details have been introduced only so far as reference to them has appeared essential to an understanding of the physiology of the plant." The list of references to the literature in the text covers 48 pages and the index 31 pages. Both of the volumes are well illustrated with tables, graphs and figures.

ARBRES ET FORÊTS.

By Léon Pardé and Maurice Pardé. Librairie Armand Colin, Paris. 17.50 francs (cloth); 15 francs (paper). $6\frac{3}{4}$ x $4\frac{1}{4}$; 224; 1938.

It is astonishing how much information the author has been able to compress between the covers of this pocket sized volume. In addition to a complete treatise on dendrology, a discussion of the effect of climatic, geological, and biological factors on the growth and well-being of trees, and of the destructive and constructive care and management of forests, the reader finds descriptions of the principal types of forests of the world, both natural and artificial, such as the coniferous forests of the northwest, the eucalypt forests of Australia, the hardwoods of the tropics, the deciduous trees of the temperate zones, the forests of the high mountain ranges of the world, all of which read like travel

talks, and makes the reader regret the absence of illustrations. Most of this descriptive material deals naturally with the forests of France, and when one recalls that this country extends from sea level on both the Atlantic and Mediterranean to the summit of Mt. Blanc, one can appreciate what a variety of forestation it contains. There is also a discussion of forestry from the commercial standpoint—lumber and paper pulp, as well as the different kinds of foods and medicines obtained from trees. The bibliography lists 48 items but there is no index.

PLANT CHEMICULTURE. *A Guide to Experiments in Growing Plants Without Soil. Second Edition.*

By C. D. Dawson and M. V. Dorn. Dawson and Dorn, Los Angeles, Calif. $1.00. 8¼ x 5¼; 110; 1938 (paper).

The growing of plants without soil, both as a hobby and as an industry has attracted world-wide interest during the past few years, and if we may hazard a prediction will in short order become a well-grounded science.

The present volume is a handbook for the successful growing of plants in chemical solutions. There is a brief comment on the nutritional requirements and the physiology of plant growth, together with a sketch of the past and present history of plant chemiculture. The majority of the space is devoted to how's, why's, and wherefore's; the equipment, chemical materials, heating, lighting, and lastly, the different chemical formulae used in the process. Brief notes on planting and the treatment of pathological conditions in plants are also included. A few paragraphs on sources of supplies, equipment, and information conclude the volume.

CRYPTOGAMIC BOTANY. *Volume* 1, *Algae and Fungi; Volume* 2, *Bryophytes and Pteridophytes.*

By Gilbert M. Smith. McGraw-Hill Book Co., New York. Vol. 1, $4.00; Vol. 2, $3.00. 9 x 6; Vol. 1, viii + 545; Vol. 2, vii + 380; 1938.

In these two volumes the student who wishes to extend his knowledge of plants below the level of seed plants has a dependable guide.

> It is written from the standpoint that a thorough knowledge of a representative series in each of the major groups is better than scraps of information about a large number. . . . It is hoped that the introductory discussion to classes, orders, and families will help call attention to those characters of the selected representatives which are of distinctive importance and those which are special to the representative itself. In certain cases, as with the diatoms and the slime molds, it has been thought more advantageous to present the group as a whole instead of discussing selected representatives. . . . An attempt has been made to present both sides of the controversial subjects, but I have not hesitated to express an opinion upon the relative merits of the arguments.

Both volumes are well illustrated and indexed, and each chapter concludes with a very useful bibliography. A valuable reference work for all biological laboratories.

HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. Lieferung 469. Abt. XI, *Chemische, physikalische und physikalisch-chemische Methoden zur Untersuchung des Bodens und der Pflanze, Teil 4, Heft 7. Ernährung und Stoffwechsel der Pflanzen.* Containing the following article: *Die Messung der osmotischen Zustandsgrössen pflanzlicher Zellen und Gewebe, by Alfred Ursprung.*

Urban und Schwarzenberg, Berlin and Wien. RM. 24. 10 x 7; 464; 1938 (paper).

There has for some time been a confusion in the definitions of such terms as osmotic pressure, turgor pressure, turgor power, absorption power, osmotic value, cane sugar value, concentration of cell sap, etc. The author carefully explains the meaning and use of these terms before proceeding with his discussion on the most appropriate methods to be employed in the measurement of various osmotic properties of different plant cells and tissues. The bibliography covers twenty closely printed pages.

APPLIED MYCOLOGY AND BACTERIOLOGY. *By L. D. Galloway and R. Burgess.*

Leonard Hill, Ltd., London. 10s. (Obtainable in North America from Chemical Publishing Co., New York. $4.00) 8½ x 5⅝; ix + 186; 1937.

As the authors admit in their foreword, one cannot compress into one small volume a complete account of mycology and bacteriology, but Galloway and Burgess have done a very fair job of outlining the possible applications of the two sciences, and of indicating where more detailed information is to be found. To anyone wanting a general survey of microbiology, or a brief sketch of some particular phase of it, this book should be helpful. The bibliographies at the ends of the chapters are excellent.

AN ECOLOGICAL GLOSSARY.

By J. Richard Carpenter. University of Oklahoma Press, Norman. $4.00. 7¾ x 5¼; x + 306 + [15]; 1938.

The rapid and continued growth of the science of ecology has evolved a terminology which has become somewhat complex and confused. By defining the science's numerous terms and whenever possible giving a reference to the source of the words, by listing synonyms, etc., this glossary will make the literature more comprehensible to those not well versed in ecological lingo. Several ecological maps (which are mostly out of print), classifications, and terminologies are appended.

CONSUMPTION AND PRODUCTION OF TOBACCO IN EUROPE. *U. S. Department of Agriculture. Technical Bulletin No. 587.*

By J. B. Hutson. Government Printing Office, Washington. 15 cents. 9⅛ x 5⅞; 114; 1937 (paper).

Much useful information is given in this bulletin for those who have to deal with the tobacco question. After the World War, changes took place in the consumption of tobacco products—there was an increase in the use of cigarettes and a decline in the use of cigars. Numerous tables on the consumption and production of tobacco in all the different countries of Europe, from 1913 to 1935, are given and a map is added showing the tobacco-producing regions in every country.

PLANT ECOLOGY. *Second Edition.*

By John E. Weaver and Frederic E. Clements. McGraw-Hill Book Co., New York. $5.00. 9 x 6; xxii + 601; 1938.

The second edition (first edition reviewed in these columns, Vol. 5, No. 1) of this standard work has been completely revised to include the newer discoveries in the rapidly progressing field of plant ecology. The bibliography alone has been enlarged from 606 to 1035 titles.

THE VEGETATION OF CRANBROOK LAKE BOTTOM, OAKLAND COUNTY, MICHIGAN. *Cranbrook Institute of Science, Bulletin No. 11.*

By Cecil Billington. Cranbrook Institute of Science, Bloomfield Hills, Mich. 20 cents. 9 x 6; 20 + 1 plate; 1938 (paper).

The great mass of vegetation appearing on the dry bottom of Cranbrook Lake less than a year after drainage seems to indicate that mesophytic plant seeds becoming embedded in silt at the bottom of lakes and streams can remain dormant and viable for an undetermined number of years.

SILVA FENNICA 40. *Finnish Game and Hunting.* [*Suomen riista- ja metsästysolot.*]

By V. M. Klemola. Society of Forestry in Suomi, Helsinki. 9⅝ x 6½; 27; 1937 (paper).

SILVA FENNICA 41. *Muhkurin Kasvisto.* [*Die Flora des Eichenwaldes von Muhkuri.*]

By A. V. Auer. Society of Forestry in Suomi, Helsinki. 9⅝ x 6½; 36; 1937 (paper).

SILVA FENNICA 42. *Metsänhoitajien Jatkokurssit 1936 II.* [*Der Fortbildungskursus für Forstmeister 1936 II.*]

Society of Forestry in Suomi, Helsinki. 9⅝ x 6½; 210; 1937 (paper).

SILVA FENNICA 43. *Suomen Metsätieteellisen Seuran 25-Vuotisjuhla 18. 4. 1934.* [*25 Years' Jubilee of the Society of Forestry in Suomi on April 18th, 1934.*] [*Fest zum 25-Jährigen Bestehen der Forstwissenschaftlichen*

Gesellschaft in Suomi am 18. April 1934.]
Society of Forestry in Suomi, Helsinki. 9⅝ x 6½; 65; 1937 (paper).

SILVA FENNICA 44. *Havaintoja kasvillisuuden kehityksestä Pohjois-Suomen kuloaloilla.* [*Beobachtungen über die Entwicklung der Vegetation auf den Waldbrandflächen Nord-Finnlands.*]
By R. Sarvas. Society of Forestry in Suomi, Helsinki. 9⅝ x 6½; 64; 1937 (paper).

SILVA FENNICA 45. *Yksityismetsätalouden edistäminen.* [*Befrämjandet av privatskogsbruket.*] [*The Promotion of Private Forestry.*]
Society of Forestry in Suomi, Helsinki. 9⅝ x 6½; 137; 1938 (paper).

BULLETIN DER SCHWEIZERISCHEN GESELLSCHAFT FÜR ANTHROPOLOGIE UND ETHNOLOGIE 1937–38. 14. *Jahrgang.*
Société Suisse d'Anthropologie et d'Ethnologie, Institut Anthropologique de l'Université, Zurich. 2 francs. 9 x 6¼; 20; 1938 (paper).

MORPHOLOGY

EMBRYONIC DEVELOPMENT AND INDUCTION.
By Hans Spemann. Yale University Press, New Haven; Oxford University Press, London. $5.00. 9 x 6; xii + 401; 1938.

The term "induction" is one that can be more easily illustrated than defined. For instance, the lens of the vertebrate eye is produced from local ectodermal tissue, but is induced by proximity of the optic cup, an outgrowth of the neurenteron. There are some species of amphibia in which the lens will not be developed if the generation of the optic cup be prevented by mutilation of the neurenteron. It is also possible in some species to divert the optic cup so that the lens is induced in an abnormal locality. Finally, it is possible in some instances to remove the ectodermal tissue from the ocular region and replace it with an implant from a different individual, not necessarily of the sames species. When the lens is induced, it exhibits the characteristics of the species from which the implant was taken, even though it may not have come from the ocular region or anywhere near it.

The possibilities of this kind in experimental investigation seem to be without limit. A remarkable technique has been perfected for making transplants of embryonic tissue in the early cleavage stages, and the 508 items in the bibliography of Dr. Spemann's book bears witness to the great amount of experimentation that has been done along this line. A great quantity of this work seems to indicate that even after the embryonic tissues have become sufficiently specialized to produce the structures for which they seem to have been destined they still retain sufficient generalization to be able to generate other structures when transplanted into other positions.

It is intriguing to speculate as to what must be the structure of an embryonic cell if the goal of its development must be determined by induction of other cells in the environment. Dr. Spemann is not sympathetic to such speculation, and he criticizes with impartiality such investigators as Driesch, Gurwitsch, Weiss, Boveri, and Child without offering any substitute theory of his own. He believes the time is not yet ripe for theorizing, and that despite the quantity of observations on embryological experiments that have already been accumulated a still greater quantity must be assembled before the field can be surveyed as a whole. In the meantime the question as to the nature of fundamental cytological structure must be held in abeyance. In this connection it is interesting to recall that about a quarter century ago it was popularly believed that cancer was the result of misplaced embryonic cells. Yet Dr. Spemann made no mention of the possibility of the induction of cancer by transplantation of healthy tissue.

It is strange that such a truly significant and important book as this should have no index, except a very brief one confined to the names of authors quoted.

TISSUE REACTIONS IN BONE AND DENTINE. *A Morpho-biological Study of the Formation and the Dissolving of Bone and Dentine.*
By Åke Wilton. Henry Kimpton, London. 15s. net. 9 x 6; 194; 1937 (paper).

While attempting to use the development

of bone and dentine as indicators in vitamin studies, the author became interested in the developmental variability of these tissues. He has been led to feel that the embryological concept of progressive determination or differentiation can somehow provide an explanation for the diverse behavior of bone and dentine cells. His investigations, while working at the Umea Hospital and at the Caroline Institute (Stockholm) as a practical pathologist, have led him to a comprehensive thesis, in description of which the present monograph was written. It covers both his correlated readings (in histology, experimental embryology, pathology, tissue culture, and biochemistry) and his own studies (on normal and rhachitic human teeth and bone, on osteolysis during experimental hyperparathyroidism and scurvy in guinea pigs, and on osteolysis associated with Paget's disease and osteogenesis imperfecta in man). The text is fully illustrated with histological figures, both colored and uncolored.

The power of precipitating the matrix substances seems to be gained by a bone or dentine cell during its differentiation: with a little differentiation, collagen is precipitated; and "with high differentiation there is also conferred the power of producing substances which act as precipitants of cementing substances and lime." These processes are reversible, but only within the limits of progressive developmental determination. In young bone cells, capable of morphological dedifferentiation, the matrix may be re-dissolved, "demasking" the cytoplasm in which it was laid down. In the reticulo-endothelial cells the processes of differentiation and of matrix-precipitation seem to be less reversible, though a certain amount of "passive" bone resorption is capable of taking place. And in physiologically aging cells, capable of little or no such dedifferentiation, only "lingering" bone resorption seems to occur.

INTRODUCTION AND GUIDE TO THE STUDY OF HISTOLOGY *for Students in Medical Schools and Colleges.*

By Avery E. Lambert. P. Blakiston's Son and Co., Philadelphia. $5.00. 9 x 6¼; xi + 542; 1938.

TEXTBOOK OF HISTOLOGY FOR MEDICAL STUDENTS.

By Evelyn E. Hewer. The C. V. Mosby Co., St. Louis. $4.50. 9¾ x 7¼; xi + 365; 1938.

Both of these texts are excellent. While, in general, they cover the same ground their methods of approach differ widely. The first, expanded from the author's *Guide to the Study to Histology and Microscopic Anatomy* is a useful guide to students who are beginners in the study of medicine. The earlier volume was almost entirely in the form of directions for laboratory study. In the present volume each of the "laboratory studies" is preceded by a general discussion of the known facts concerning the structures to be studied. The work is planned to furnish a foundation for the student's further work in physiology and pathology. The references for suggested readings (only English titles are given) are designed for use as additional readings—especially in subjects that are open to question or are controversial. Both the illustrations (185 in number, some of them colored) and the index are adequate.

The second of these texts is more detailed than the first. It is the outcome of twenty-one years' experience in teaching medical students. "Emphasis is laid throughout on the 'physiological' appearances and their relation to function in contradistinction to a fixed, so-called 'normal' state. The reactions of tissues to various conditions are briefly described in order to help the student to distinguish between variations of structure that fall within physiological limits and variations that fall outside these into the realm of histopathology." The 340 illustrations (mostly original) either are microphotographs to show the general structure under a low magnification or are diagrammatic drawings. There is no list of suggested readings but there is an appendix on histological methods and a useful index.

THE ESSENTIALS OF HUMAN EMBRYOLOGY.

By Gideon S. Dodds. Second Edition.

John Wiley and Sons, New York; Chapman and Hall, London. $4.00. 9 x 5¾; ix + 316; 1938.

Retained in this volume are all the features of the first edition (cf. Q. R. B. Vol. 5, p. 376) with the addition of new material from recent embryological work. Due to the increased knowledge of the sex hormones, the chapter entitled "Ovulation, menstruation, and pregnancy," has been rewritten. While giving an adequate presentation of the material the author has endeavored to make it clear and brief, recognizing the necessity for this in a general embryology course for medical or pre-medical students. The book treats of the germ cells, stages of development, the placenta and fetal membranes, and then gives the origin and development of the structures in each of the organ systems. An excellent group of figures and diagrams illustrates the text and the volume is well indexed.

UNTERSUCHUNGEN ÜBER DIE AUGENHÖHLEN DES MENSCHEN IN VERSCHIEDENEN LEBENSALTERN.

By Per Pallin. Isaac Marcus Boktryckeri-Aktiebolag, Stockholm. 5 Swedish kr. 107; 10¼ x 7¼; 1937 (paper).

This thesis from the University of Uppsala is a report of an investigation on the evolution of the orbit from fetal to adult life. The author's material included 440 skulls at various ages from birth to adult (not including senile), and 6 fetal skulls. At the beginning of the second month of fetal life the eyes look lateral, in the third the angle is reduced to 105 degrees and at birth attains 71 degrees. It converges a further 3 to 5 degrees by maturity. The work is illustrated with photographs and diagrams, includes several tables and a bibliography of over 100 titles.

ATLAS OF CAT ANATOMY.

By David B. Horsburgh and James P. Heath. Stanford University Press, Stanford University, California; Oxford University Press, London. $1.00. 11 x 8¼; 39 leaves; 1938.

All text has been omitted from this little volume on the anatomy of the cat. It consists of simple pen-and-ink drawings (42 in number), appropriately labeled, of the various systems of this common laboratory animal. There is no doubt that the atlas will prove a boon to students of cat anatomy.

THE DORSAL SPINE OF CLADOSELACHE. THE NEUROCRANIUM AND JAWS OF CLADOSELACHE. *Scientific Publications of the Cleveland Museum of Natural History, Vol. VIII, No. 1.*

By John E. Harris. Cleveland Museum of Natural History, Cleveland. 30 cents. 9¼ x 6¼; 12 + 2 plates; 1938 (paper).

This investigator reports the presence of a large spine situated in front of the first dorsal fin in two species of *Cladoselache* studied from specimens in the Cleveland Museum. This spine shows somewhat more primitive features than that in *Ctenacanthus*, thus indicating that *Cladoselache* is not the most primitive of cladodont sharks. A description of two neurocrania with their associated mandibular and hyoid arches is also given.

MORPHOLOGIE UND HISTOPHYSIOLOGIE DER NORMALEN SCHILDDRÜSE. *Zwanglose Abhandlungen aus dem Gebiete der Inneren Sekretion. Band 3.*

By B. Eggert. Johann Ambrosius Barth Verlag, Leipzig. RM. 13.50. 9⅜ x 6¼; [4] + 113; 1938 (paper).

This is a complete study of the histology, histogenesis, histophysiology, and morphology of the thyroid in both animals and men. There are 33 excellent illustrations and an extensive bibliography.

PHYSIOLOGY AND PATHOLOGY

LECTURES ON THE EPIDEMIOLOGY AND CONTROL OF SYPHILIS, TUBERCULOSIS, AND WHOOPING COUGH, AND OTHER ASPECTS OF INFECTIOUS DISEASE. *The Abraham Flexner Lectures, Series Number Five.*

By Thorvald Madsen. Published for Van-

derbilt University by Williams & Wilkins Co., Baltimore. $3.00. 8 x 5¼; xv + 216; 1937.

The first lecture deals with control of venereal disease in Denmark, with special reference to syphilis. The results are indeed remarkable, due partly to special legislation that makes treatment compulsory if necessary, and partly to the high level of education of the Danish people. The decrease, especially after the War (illustrated by a series of graphs), is more striking in Copenhagen and some other towns than in the rural districts.

In the second lecture the mechanism of bacterial infection is discussed, mostly according to investigations by Dr. Ørskov and collaborators in the Danish State Serum Institute. From these comprehensive experiments we may quote:

> In all studies on peroral infection it was found that the ways by which the infections spread were always the same, namely, by steps along the regional lymph channels of the digestive tract till the regional glands were reached. In some cases the infection did not extend any farther. Whenever there was a generalization of the infection, however, it always started from the regional lymph stations, passing along the lymphatics, reaching the blood stream by way of the thoracic duct and other centripetal lymph channels, getting thus to the organs and peripheral glands. . . . The bactericidal qualities of the blood appear not to play any particular rôle, but the fixed phagocytes, especially in the liver and the spleen play a leading part in this process.

The third chapter deals with tuberculosis in Denmark, where the mortality figure has long been the lowest of all European countries. The death-rate from tuberculosis in 1935 was 52 per 100,000, that is about the same as in the whole of the United States. Madsen is in favor of the BCG vaccination although not giving a statistical proof. He furthermore shows that bovine infection plays a considerable rôle, at least in Denmark, even in lung tuberculosis. In connection with his well-founded opinions on relative immunity in tuberculosis the following conclusion from his summary may be quoted: "At present, it seems to me, it might be too risky in a country like ours, even if it were practicable in a few places, to eradicate tuberculosis entirely, but preferably to modify the course of this infection in such a way that it becomes protective instead of destructive."

In the fourth lecture the influence of seasons on infection is illustrated for the most important infectious diseases by a great many graphs. These matters are fairly well-known although the single factors of the weather have not yet been clearly enough elucidated. In the closing chapter a comprehensive survey is given on whooping cough research, a field in which the author and the Danish Serum Institute have led for many years. Experiences in Faroe Islands and Denmark point to the conclusion that early vaccination is the most important method in the campaign against this disease. However, the author says in this remarkable study,

> . . . as long as there is no chance of our banishing these diseases from every country of the world, we must be careful not to banish them from a single country, for by so doing we run the risk of experiencing what we have observed under the measles epidemic on the Faroe Islands, namely, when a disease finally returns after a long absence, it attacks young and old without discrimination, and readily assumes that pernicious character so often observed in diseases among a "virgin population." . . . It is far better to retain the epidemics under the form of "childhood diseases" whose attacks render the entire population practically immune; . . .

THE CAUSE OF CANCER.

By David Brownlie. Chapman and Hall, London. 7s. 6d. net. 7¼ x 4¾; [6] + 208; 1938.

It is surely a curious thing when an engineer and fuel technologist—even an outstanding man in his field—gives a new theory on cancer. "The cause of cancer" is of course an important head-line, and a medical man or a biologist would hardly, at the present stage of research work, have the courage to use this label. But perhaps there is a great advantage in knowing only a little or maybe nothing of the enormous amount of clinical observation, experimental work in cancer pathology, statistics, and literature that has been done all over the world for many years past. Maybe this is the way to find out some day the real cause of malignant growths, if there is a single one.

Brownlie is of the opinion that cancer in human beings is largely due to

> complex poisonous products from high temperature carbonization and general heat decomposition, and

combustion of coal and other carbonaceous material, which largely enter the body in food, with manufactured towns gas and the smoking of meat, fish, and other products playing a primary part. Or in other words that cancer is essentially a carbonization and combustion disease. (P. 69).

The author's theory is based on the fact that the manufactured town gas, almost always coal gas, has been used more and more for general domestic and industrial purposes, in some countries more than in others, and in England especially more than in the United States. On the other hand he is of the opinion that cancer mortality has increased enormously, and most in England and Wales where the death rate is now about seven times higher than 80 years ago! This view is supported by very rough statistics and a few figures of crude mortality rates. The author has never dealt with statistics, otherwise he would perhaps know that there is no real increase shown by more precise statistics by age groups, or at most only a small one. From this point of view the new theory of the author cannot be proved true. There might, however, be some truth in supposing that certain benzene ring hydrocarbons formed by high temperature carbonization and, contained in manufactured town gas, play a part in the cancer etiology—but that should be proved very carefully by experimental work before going into a general theory. The fact that cancer occurs mostly in the higher age groups as well as in special localizations is not explained by the supposition of a simple gas poisoning.

SYPHILIS, GONORRHEA AND THE PUBLIC HEALTH.

By Nels A. Nelson and Gladys L. Crain. Macmillan Company, New York. $3.00. 8 x 5¼; xvii + 359; 1938.

This book constitutes an attempt to inform the layman about venereal diseases and the means of controlling them. In non-technical language the authors describe the etiologic agent, the clinical signs and treatment of syphilis and of gonorrhea. In addition, they summarize what data there are relative to the incidence and distribution of these diseases in the general population. The latter part of the book is taken up by a discussion of the ways and means of successfully controlling not only syphilis, as seems to be the limited objective of the present public health program, but also gonorrhea. In their view:

> The control of the genitoinfectious diseases is a problem, not of diagnosis and treatment alone, but of discovering how to persuade people to suspect infection, seek a diagnosis and take treatment. It is a problem in how to fit a program to human nature, human weaknesses, misunderstandings, ignorance and difficulties, all mixed up with an often broken, but none the less exacting moral code. The health officer may sally forth with a badge and a club, with authority and powers, and catch a few of the less fleet-footed; but he will not control genitoinfectious diseases thereby. They may, and probably will disappear, but it will be only to get under cover.

This sane attitude is welcome and the details of the program which they present should be given serious study. But Reginald the Office Boy says that some of the bad boys he knows tell him that you don't have to persuade people to suspect infection when they have gonorrhea. They will know about it, and how!

THE BRAIN AND ITS ENVIRONMENT.

By Joseph Barcroft. Yale University Press, New Haven; Oxford University Press, London. $2.00. 8 x 5½; xii + 117; 1938.

The scope of this book, based on the Terry Lectures at Yale delivered by Dr. Barcroft, Professor of Physiology at Cambridge University, is indicated by the headings of the three chapters which comprise the excellent content: The activity of the brain in mid-foetal life; The activity of the brain at birth; Mental efficiency considered in relation to some properties of the blood. Dr. Barcroft adheres closely to known facts, summarizing in the first chapter basic observations of his own and of other physiologists on the physiology of the embryo. The second chapter deals particularly with alterations in the oxygen supply to the brain associated with the transition from prenatal to postnatal life in the sheep. In the final chapter, the effects on the higher mental processes in man of reduction and increase in body temperature, oxygen want and excess, carbon dioxide deficiency and excess, and hypoglycemia are considered. Dr. Bar-

croft points out that experimental results lead to the conclusion that nervous function does not appear as a result of need for that function, but is present, "anticipating" the need long before it exists.

The book is an important and specific presentation of the essential work to date in a pioneer field of research. The book is indexed and appropriate references are appended to each chapter.

TUBERCULOSIS AND LEPROSY. *The Mycobacterial Diseases. Symposium Series, Vol. 1. Edited by Forest Ray Moulton. Publication Committee: Esmond R. Long, George W. McCoy, Earl B. McKinley, Malcolm H. Soule, Wm. Charles White. The American Association for the Advancement of Science, Washington, D. C.* $2.50. 10¼ x 7½; 133; 1938.

This volume includes the papers presented at the seventh symposium (held in Denver, June 1937) organized by the Section on Medical Sciences of the American Association for the Advancement of Science. It deals with the whole complex of diseases caused by acid-fast-bacteria, among which, of course, tuberculosis still plays by far the most important part. After a short introduction on occurrence and properties of the whole acid-fast family or *Mycobacterium*—a genus of the Mycobacteriaceae—the pathology and bacteriology of tuberculosis is discussed—five general headings; tuberculosis in animals—six headings; and leprosy—six headings. A concluding section gives a summary and unification of all the different problems discussed. The volume—the work of specialists—gives a valuable insight into the present state of knowledge in pathology and bacteriology of tuberculosis and leprosy. Unfortunately epidemiology and statistics are not included in this symposium.

THE CONQUEST OF CHOLERA: *America's Greatest Scourge.*

By J. S. Chambers. The Macmillan Co., New York. $4.75. 8½ x 5⅝; xiv + 366 + 40 plates; 1938.

Asiatic cholera caused thousands of deaths in this country during the period from 1832 when it was first introduced to 1892 when the last epidemic occurred. From the official reports and from newspaper and other accounts of the period the author has ably pieced together the important epidemiologic features of this disease. In a vivid style he discusses the introduction of cholera into this country, traces its course throughout the nation, describes the futile efforts to control it and how it was stopped at last by the successful application of bacteriologic and epidemiologic discoveries. Written in non-technical language, this book should be of general interest because it presents a summary of the great progress of medicine during the 19th century and an excellent illustration of some of the immediate practical benefits derived from it.

PATHOLOGY. *Clio Medica.*

By E. B. Krumbhaar. Paul B. Hoeber, Inc., New York. $2.00. 6½ x 4½; xvii + 206; 1937.

The editor himself has contributed an interesting volume to the Clio Medica series on the history of medicine, and, in a departure from the usual method, has placed his emphasis on ideas and trends in the development of pathology, with the names of great men coming in only as those men influenced the field. With this in mind, a three-part division of the book is apparent, with the cell concept and its application to pathology marking the change from "the earliest halting observations," "the systematized, voluminous studies," and "the tissue concepts" to "the rational, integrated pathology" of modern times. Added to the general appeal that any brief history has, there is here, as a special attraction for the medical reader, a list of the early chairs of pathology and pathological anatomy, as well as a list of Pathologic Milestones which includes the dates of many "first descriptions." The statement in the bibliography that the Sydenham Society Publications, Old and New Series, London, 1859–1907, give good translations of many of the classics of pathology, is worth noting, too.

LE PHÉNOMÈNE DE LA GUÉRISON DANS LES MALADIES INFECTIEUSES.

By F. D'Hérelle. Masson et Cie, Paris. 75 francs. 10 x 6½; 414; 1938 (paper).

A discussion of bacteriophages and bacterial mutations is given in the first three chapters of this volume. The epidemiologist will find the second section of particular interest; that dealing with the infectious diseases studied by the author in various parts of the world over a period of twenty years. On the basis of these studies he has formulated a theory as to the manner by which such diseases may be treated and epidemics controlled through bacteriophages, which are themselves transmissable. There is an index, bibliography, and appendices which give methods of preparation of bacteriophages and determination of anti-phages.

RADIOKYMOGRAPHIE DU COEUR ET DES VAISSEAUX.

By Emile Bordet and H. Fischgold. Masson et Cie, Paris. 30 francs. 7⅞ x 5½; 134; 1937 (paper).

For anyone interested in the new method of studying the movements of the outlines of the heart, this will be a very useful little book. In radiokymography one either moves a grid in front of the film during exposure, or the film is moved back of the grid. The jagged, saw-tooth edges which then appear around the heart shadow are analyzed, often with the help of a photoelectric cell and a recording galvanometer. It is hard to say yet how much new information of value to the physiologist and clinician is going to be obtained in this way, but the method is certainly interesting. The book is interestingly written and well illustrated.

DANCE OF DEATH.

By Helen McCloy. William Morrow and Co., New York. $2.00. 7½ x 5; viii + 303; 1938.

Written in popular style, *Dance of Death* is an exciting murder mystery in which the experiments of Mayer, Magne, Plantefol, and Derrien on 2, 4 di-nitro-phenol, or thermol, play an important part. Their research on thermol may be found in the *Annales de Physiologie et de Physicochimie Biologique*, 1932, Vol. 8, pp. 1–194.

This unusual story concerns itself with an illegal exploitation by business racketeers of thermol as a reducing drug, a young woman dying from a fatal heat stroke with the temperature at nine above zero, and the solving of the crime by a psychiatrist in search of "psychic fingerprints." Of especial interest are Miss McCloy's descriptions of the autopsy and other pertinent medical and chemical facts concerning the lethal internal heat stroke caused by thermol.

METHODS OF TISSUE CULTURE.

By Raymond C. Parker. With a Foreword by Alexis Carrel. Paul B. Hoeber, Inc., Medical Book Dept. of Harper and Bros., New York. $5.00. 9¼ x 6¼; xxxii + 292; 1938.

The techniques of tissue culture in use at Carrel's laboratory at the Rockefeller Institute are lucidly described and explained in this manual. Dr. Parker's purpose is to make these reliable procedures more generally available, for in the words of Dr. Carrel, "Poor techniques always engender meaningless results."

The history of tissue culture is briefly reviewed in the foreword and in the introduction. There are 63 illustrations of cultures, special equipment, apparatus arrangements, and laboratory procedures. In the bibliography, 753 selected references covering the many diverse fields of tissue culture are listed as a general introduction to the more extensive literature available on tissue culture techniques. An important reference work.

PNEUMONIA AND SERUM THERAPY. *Revised Edition of Lobar Pneumonia and Serum Therapy.*

By Frederick T. Lord and Roderick Heffron. Commonwealth Fund, New York; Oxford University Press, London. $1.00. 8¼ x 5¼; viii + 148; 1938.

This is a revised edition of a book published in 1936 by the Commonwealth

Fund. It discusses the use of antipneumococcic serum in the treatment of pneumonia of the several types, and it is full of practical and detailed information as to the technic of using these serums. It tells how to organize a program for pneumonia-control in a community, and it gives interesting and encouraging figures showing the reduction in mortality which has been obtained with serum in the several types of pneumonia. This book should be an almost necessary addition to the library of anyone engaged in this field of work.

THE PHARMACOLOGICAL SHOCK TREATMENT OF SCHIZOPHRENIA. *Revised English Edition. Nervous and Mental Disease Monograph Series No. 62.*

By Manfred Sakel. With a Foreword by Otto Pötzl. Authorized Translation by Joseph Wortis. Nervous and Mental Disease Publishing Co., New York and Washington. $2.75. 9 x 6; xviii + 136; 1938.

This book contains a detailed description of the procedure for treating schizophrenia by the insulin shock method which the author originated. The four phases in the basic method are outlined and discussed. Factors modifying the technic in the individual case are well presented, and the management of complications considered. Nine case histories are presented in detail. The book closes with a theoretical but interesting discussion of the possible mechanisms by which the therapeutic results are obtained. The material is presented without pretension, but on an optimistic note which it is hoped further experience will justify.

MÉLANGES JEAN DEMOOR. *Volume Jubilaire offert à M. le Professeur Jean Demoor à l'occasion de son élévation à l'Honorariat.*

Various Authors. Masson et Cie, Paris. 60 francs. $9\frac{3}{4}$ x $6\frac{1}{2}$; 512; 1937 (paper).

As a tribute to Jean Demoor, his colleagues and contemporaries have contributed articles which have been collected and made into this volume. Since 1886 when he first published a list of the Cicindelidae, the French physiologist has been publishing continuously; the list of his works alone covers thirteen pages.

Most of the articles are brief and of interest mainly to physiologists. The many illustrations, tables and graphs throughout the text and the reference lists which usually accompany the articles make this a really useful volume.

EAT AND KEEP FIT.

By Jacob Buckstein. Emerson Books, New York. $1.00. $5\frac{1}{2}$ x $8\frac{1}{4}$; 128; 1938.

Buckstein has here written for laymen an excellent little book on diet. The essential facts have been well chosen and well presented, and the intelligent layman who has not already read two or three books of this type will doubtless get pleasure and profit from reading this one. There are explicit directions for the use of a fourteen-day type of reduction diet, and there are lists of 100-calorie portions and of foods containing the several vitamins and minerals essential to health.

LIFE, HEAT, AND ALTITUDE. *Physiological Effects of Hot Climates and Great Heights.*

By David B. Dill. Harvard University Press, Cambridge; Oxford University Press, London. $2.50. $7\frac{7}{8}$ x $5\frac{1}{2}$; xiv + 211; 1938.

This book, based on work done in the Fatigue Laboratory of Harvard University, analyzes the physiological mechanisms by which organisms adapt themselves to life in hot climates, wet or dry, and in high altitudes. As one becomes acclimatized to heat the concentration of chloride in the sweat becomes less and the amount of sweat greater. In adaptation, both to heat and to high altitudes, there is much individual variation.

THE LIVING BODY: *A Text in Human Physiology.*

By Charles H. Best and Norman B. Taylor. Henry Holt and Co., New York. $3.60. $8\frac{1}{2}$ x $5\frac{5}{8}$; xxii + 563 + 15 plates; 1938.

An excellent physiological text, this manual is designed for use in colleges, nursing schools, dental and agricultural institutions. It is based upon the authors' former text, *The Human Body and Its Functions*. There are 298 illustrations, 15 of which are colored plates. The drawings of the anatomy and histology of organs and cells are extremely helpful for a better understanding of the discussions on normal and pathological bodily functions.

STUDIES ON THE PHYSIOLOGY OF THE EYE: *Still Reaction, Sleep, Dreams, Hibernation, Repression, Hypnosis, Narcosis, Coma, and Allied Conditions.*

By J. Grandson Byrne. Re-issue with Supplement and New Index. H. K. Lewis and Co., London. 40s. net. $9\frac{5}{8}$ x $5\frac{3}{4}$; xii + 440; 1938.

This book was first reviewed in Vol. 9 (p. 115) of the QUARTERLY REVIEW. No changes have been made in this re-issue except for the addition of a supplement on the effect of stimulation of the cortex cerebri upon the effector mechanisms which mediate movements of the iris and membrana tympani. The index has been revised and much condensed.

KURZES WÖRTERBUCH ZUR GESCHICHTE DER MEDIZIN.

By B. Mayrhofer. Gustav Fischer, Jena. RM. 10.50 (bound); RM. 9 (paper). 10 x $6\frac{3}{4}$; iv + [4] + 224; 1937.

This dictionary is useful for a brief insight into the development of medical history and science, especially from the clinical point of view. Of course it cannot be very complete, the newer developments of hygiene and preventive medicine, biometry and medical statistics being barely mentioned. Names like Galton and Pearson are entirely omitted while those of many others of much less importance in modern times are included.

TEACHING PROCEDURES IN HEALTH EDUCATION.

By Howard L. Conrad and Joseph F. Meister. W. B. Saunders Co., Philadelphia and London. $1.75. $7\frac{3}{4}$ x $5\frac{1}{4}$; 160; 1938.

Teachers and student-teachers of hygiene in secondary schools might find this text an aid in their work. Various methods to stimulate learning are presented not only by actual application of health procedures by the student, but also by planned lessons, readings, and oral and written tests.

THE TRUTH ABOUT VIVISECTION.

By Sir Leonard Rogers. J. and A. Churchill, London. 5s. net. $7\frac{3}{4}$ x 5; x + 182; 1937.

The pros and cons of vivisection as presented before the Royal Commission of 1906 are presented here along with evidence of later date. Although in his preface the author states that all inquirers may form their own conclusions, sensible people will be in no doubt about the correct one.

BIOCHEMISTRY

SPECTROSCOPY IN SCIENCE AND INDUSTRY. *Proceedings of the Fifth Summer Conference on Spectroscopy and Its Applications Held at the Massachusetts Institute of Technology, Cambridge, Massachusetts July* 19–22, 1937.

A Publication of the Technology Press, Massachusetts Institute of Technology. John Wiley and Sons, Inc., New York; Chapman and Hall, Ltd., London. $3.00. 10 x 7; vii + 134; 1938 (paper).

Within this volume twenty-nine short papers are presented, all of which were selected from the 1937 summer conference on spectroscopy. These papers give the practical applications of spectroscopy to the fields of chemistry, metallurgy, electricity, botany, experimental physiology, and medicine. A few of particular interest to biologists are the following: The analysis of the skin and urine for traces of lead; The importance of the spectrograph in establishing the diagnosis of argyria or silver poisoning; Spectrophotometric studies in the metabolism and molecular structure of hemoglobin derivatives; Some applications of spectroscopic

methods in experimental physiology; and On the origin of light-sensitivity in seeds.

A list of references is given at the end of most sections, and the entire volume is well indexed.

STUDIES ON BIOLOGICAL OXIDATION AND SOME OF ITS CATALYSTS (*C_4 Dicarboxylic Acids, Vitamin C and P, etc.*).

By Albert v. Szent-Györgyi. Karl Rényi, Budapest; Johann Ambrosius Barth, Leipzig. RM. 6.50 (bound); RM. 5 (paper). 9½ x 6¾; 98; 1937.

The author sums up his extensive research on the mechanism of the seemingly elementary reaction, $2H + O = 2H_2O$, the study of which has led to such divers results as the discovery of the catalytic nature of C_4 dicarboxylic-acids, the identification of ascorbic acid as vitamin C, and the discovery and isolation of vitamin P.

The principles and theories of biological oxidation in both plants and animals are outlined and carefully analyzed. The author's work in biochemistry has led him to conclude that ". . . there can be no real difference in the fundamental chemical mechanisms of plants and animals." He further adds, "The existence of vitamins is convincing evidence on this line, as it shows that plants and animals work with the same cogwheels."

TRAITÉ DE CHIMIE ORGANIQUE. *Tome VIII. Fascicule I et II. Quinones. Cétènes. Aldéhydes-Alcools et Cétones-Alcools. Oses et Holosides. Généralités sur les Hétérosides. Amidon. Cellulose. Lichénine. Soies Artificielles. Industries des Matières Amylacées. Industries des Sucres. Carbonisation des Bois. Aldéhydes-Phénols et Cétones-Phénols.*

By J. Amiel, M. Battegay, P. Baud, G. Champetier, R. Dolique, J. Duclaux, M. Frèrejacque, V. Hasenfratz, H. Hérissey, A. Hieulle, J. Lichtenberger, I. Marszak, H. Pariselle, J. Rabaté, M. Schoen, M. Sommelet, R. Sutra. Published under the direction of V. Grignard, G. Dupont, R. Locquin and Paul Baud. Masson et Cie, Paris. 335 francs (paper); 375 francs (cloth). 10 x 6½; xix + 1256; 1938.

This is the sixth volume to appear of a 15 volume treatise on organic chemistry. Preceding parts have been noticed in these columns. The high standards of scholarship and usefulness characteristic of the work as a whole are well maintained in this volume.

THE BIOLOGICAL STANDARDIZATION OF THE VITAMINS.

By Katharine H. Coward. William Wood and Co., Baltimore. $4.50. 8½ x 5½; viii + 227 + 7 plates; 1938.

This is a manual on the quantitative determination of vitamins in foods, preparations for therapeutic use, and products obtained in chemical investigations of vitamins. Both the practical and mathematical aspects of the subject are adequately treated. A valuable reference work.

HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. *Lieferung* 470. *Abt. V. Methoden zum Studium der Funktionen der einzelnen Organe des tierischen Organismus, Teil* 10, *Heft* 8 (*Schluss*). *Allgemeine und vergleichende Physiologie* (*Ergänzung zu Abt. V., Teil* 2). Containing the following article: *Stufenphotometrische Methoden der Blut- und Harnanalyse*, By Carl Urbach.

Urban und Schwarzenberg, Berlin. RM. 13.50; (25 per cent reduction outside of Germany). 10 x 7; 175; 1938 (paper).

This *Lieferung* describes gradation photometric methods utilized by various workers in the determination of 24 chemical constituents of the blood and 15 of the urine. Results for each are presented in tabular form.

SEX

YOUTH AND SEX. *A Study of* 1300 *College Students.*

By Dorothy D. Bromley and Florence H. Britten. Harper and Bros., New York and London. $3.00. 8⅝ x 5¾; xiii + 303; 1938.

This is the report of a unique investigation

concerning the sex mores of college students. The authors visited 46 colleges and universities, personally interviewed 276 students of both sexes and in addition obtained answers to a prepared questionnaire from 1088 others. They found that about 50 per cent of the males and 25 per cent of the females had had premarital intercourse. The authors classify the students into several groups according to their attitude and behavior and discuss the characteristics of each in some detail with illustrative case histories. In the opinion of the authors the main conclusion to be drawn from their investigation is that the youngsters are keenly aware of the problems of sex and eager to learn how to solve them, but demonstrate the insufficiency of what instructions on the subject they may have received. Since this represents the first attempt to obtain factual information on the subject little can be said regarding the significance of the findings. On the basis of these data no one can justly say whether or not this generation is going to the dogs and the authors wisely avoid any conclusion on this point. There is a foreword by Raymond Pearl.

THE ART AND SCIENCE OF MARRIAGE.
By Esther B. Tietz and Charles K. Weichert. With an Introduction by Morris Fishbein. Whittlesey House, London. McGraw-Hill Book Co., New York. $2.50. 8 x 5½; viii + 279; 1938.

One might call this book a fundamental course in the physiology of the reproductive system. It also touches upon the anatomy and physiology of other parts of the body, thus leading one by a somewhat circuitous path around to the so-called science of marriage. As for the discussion of artful tactics, the descriptions which the authors give in the first fifty pages differ little from what may be found in other books on sex and marriage.

SEX SATISFACTION AND HAPPY MARRIAGE.
By Rev. Alfred H. Tyrer. Foreward by Robert L. Dickinson. Emerson Books, New York. $2.00. 5¼ x 7⅞; 160; 1938.

"This book has its source in the fountain of bitter sorrow and the remembrance of scalding tears." Reverend Tyrer, along with the scores of other sex handbook writers, has undertaken his work with the deepest sense of responsibility. He has produced a manual for use by engaged couples and also "for use in their work by doctors, the clergy, social workers, lawyers, and others in the advisory professions, who may find recommendation of this book a convenient and time-saving method of imparting advice."

BIOMETRY

STATISTICAL METHODS. *Applied to Economics and Business. Revised.*
By Frederick C. Mills. Henry Holt and Co., New York. $3.75. 8½ x 5⅝; xix + 746; 1938.

The principal feature of this revision of Mill's well-known textbook is the addition of chapters on the newer biometric approach to problems of sampling and analysis of variance. Otherwise the order of exposition in this edition is the same as in the previous one. After an introductory chapter on statistical methods in economics and business, those that follow concern graphic representations, averages, measures of dispersion, index numbers, curve fitting, correlation and elementary probability. In the appendices the author describes the least square method, the binomial distribution and special curves such as that of Gomperz and the logistic. Useful tables are also included. From this brief outline it is seen that the book contains information on practically every aspect of elementary statistical technique. The method of exposition is unusually clear and the illustrative examples well chosen.

LA DURÉE EXTRÊME DE LA VIE HUMAINE. *Actualités Scientifiques et Industrielles, 520. Statistique Mathematique, II.*
By E. J. Gumbel. Hermann et Cie, Paris. 18 francs. 10 x 6½; 65; 1937 (paper).

The author outlines a method of determining the range of variability of the

oldest age that can be attained by man. He first postulates that there is no definite limit to the possible age that can be reached, i.e., that the upper extreme of the mortality curve approaches zero only asymptotically. Then, by means of simple and elegant theorems on probability he arrives at a measure of the expected deviations of the highest age. This measure is a function of the size of the sample but is independent of the form of distribution of the deaths at the oldest age. It is computed from the usual constants of a life table. Applications of the method is made to data for Sweden, Switzerland, United States, India and Australia. A great deal of ingenuity has been demonstrated in the development of this type of analysis but whether it can be successfully utilized in the study of the biology of death remains to be seen.

THE KELLEY STATISTICAL TABLES.

By Truman L. Kelley. The Macmillan Co., New York. $4.50. 11 x 8½; [6] + 136; 1938.

The Table of Contents of this book will furnish the reader, particularly the statistician, with a general idea of its usefulness: Construction and accuracy of tables; Uses of tables; Table I. Eight-place normal distribution, simple correlation, and probability functions; Table II. Four-place χ^2 functions; Table III. Ten-place cubic interpolation coefficients; Table IV. Ten-place quintic interpolation coefficients; Table V. Eleven-place septic interpolation coefficients; Table VI. Eight-place square roots; Table VII. Constants frequently needed.

FREQUENCY CURVES AND CORRELATION. *Third Edition.*

By W. Palin Elderton. University Press, Cambridge; Macmillan Company, New York. $3.75. 8½ x 5½; xi + 271; 1938.

This is the standard text-book on the Pearsonian system of frequency curves. In this third edition (second edition reviewed in Vol. III, No. 2) the chapters on standard errors, the test of goodness of fit, the correlation ratio and contingency have been rewritten.

PSYCHOLOGY AND BEHAVIOR

PSYCHOLOGY DOWN THE AGES. *In two volumes.*

By C. Spearman. Macmillan and Co., London. $7.50 per set. 8¾ x 5⅝; Vol. 1, xi + 454; Vol. 2, vii + 355; 1937.

This is a praiseworthy and, to the layman, certainly a most welcome attempt to clarify the progress of scientific psychology. "We will consider what wisdom it has through all the ages attained, accumulated, and preserved. In particular, we will see how far and in what direction it has gone beyond the confines of common sense—thereby meaning the knowledge shared by the generality of mankind and not confined to mental specialists."

The book is divided into five main sections. Section A deals with the development of the science of the *psyche*, and this is in large part historical. Section B discusses "the main criticisms of the attempts to construct psychology along the 'oligarchic' patterns of 'faculties' or 'powers'. Most of these criticisms—notably, that these faculties have been fantastically regarded as so many substances or agents—would appear to be devoid of foundation." Section C examines "The history of psychological progress in respect of the constitution of the psyche . . ." Section D inquires into the laws governing the *psyche*, and Section E endeavors to find out individual differences—"not that wherein people agree, but that wherein they differ." This latter section is in many ways the most interesting. The author discusses correlation coefficients, the discovery and nature of the factor "G" discovered by himself and his coworkers, specific factors of ability, and orectic factors. For a more intelligible discussion of the factors G (general intelligence) and S (specific intelligence) the reader would probably do better to consult a former book of the author's—*Abilities of Man*. It is interesting to note that (page 287):

> the general tide of psychology seems to have arrived at conceiving the principle of mind, the "psyche,"

as an Individual who Feels, Knows, Acts; who does so in a manner more or less well adapted to three intricately combining and often conflicting tasks; those of preserving Himself, his Family and his Society. . . . And so, after two thousand years of study, we might seem to come to a Mind which—save for the larger credit allowed to evolution—is disconcertingly similar to what it was originally supposed to be by common sense.

OBSESSIONS AND CONVICTIONS OF THE HUMAN INTELLECT.

By F. W. Westaway. Blackie and Son, London and Glasgow. 10s. 6d. net. 8½ x 5¾; xi + 528 + 4 plates; 1938.

This book calls to mind the words of Prince John at the revivification of Falstaff, "That is the strangest tale that e'er I heard." Not only are many strange incidents of historical interest recounted here, but the book itself is such a strange mixture of profound erudition and egregious bosh that the reader can hardly believe that it all came from the same pen. It is impossible to speak of the work as a whole; the topics cry for separate treatment, and such treatment is of course precluded by lack of space.

The author is weakest when he discusses the fourth dimension. Like Lord Kelvin, he refuses to believe anything of which he cannot see a working model. The fourth dimension is therefore a figment of the physicists and must be rejected *in toto*. Space of three dimensions was good enough for Euclid and the author finds it good enough for him. There is no space-time continuum, only space and time continua, the one with three and the other with one dimension respectively.

This argument ought to make the author reject also the modern theory of atomic structure, for it teaches that the subatomic particles are fundamental entities that manifest themselves at one time as matter and at another as energy, and certainly no one could construct a working model of such a particle. Yet he accepts this theory—a procedure which is reminiscent of straining out gnats and swallowing camels.

The author's discussion of perpetual motion and of squaring the circle both suffer from misplaced emphasis. The fallacies which he exposes are more or less obvious, but there are other fallacies which are not so obvious and which he ignores, of which the explanations might be read with profit.

On the other hand, his treatment of such subjects as witchcraft and alchemy is much happier. While these topics do not come strictly within the scope of science they have a scientific aspect. We are apt to think of these as digressions from the straight and narrow path of scientific progress, as if they were abnormalities that might have been avoided. Yet we learn here that both were the inevitable outcome of the trend of past centuries. The author points out that persecutions for witchcraft were confined almost exclusively to countries where the church had been disestablished, thus supplying aid and comfort from an unexpected source to the advocates of antidisestablishmentarianism.

Finally, to the treatment of metaphysics and theology must be accorded really high praise, though even here the critic who enjoys hunting for flaws will be successful, for the author apparently believes that the Apostle's Creed of modern Protestantism is identical with that of the same name urged on the Council of Nicaea by Eusebius. But this is a detail of little importance, as it detracts nothing from the conclusions finally drawn by the author. If the chapters on physical science could have been omitted the bulk of the work would have been reduced a third, and its value and influence would have been enhanced greatly. All told, this is really a very remarkable book, despite the criticism we have given it.

WATER-DIVINING. *New Facts and Theories. By Theodore Besterman. Methuen and Co., London.* 7s. 6d. net. 7⅜ x 5; ix + 207 + 2 plates; 1938.

As the sub-title states this current volume augments all that was written in 1926 on this highly controversial subject by the late Sir William Barrett, F.R.S. and the present writer. The new evidence consists of authentic records and detailed reports of the work of various dowsers, in different parts of the world, whose

successes are demonstrable. Personal accounts of how certain dowsers react physically and psychically when actively engaged in their profession, supply much needed information. The verdict is still divided, however, between those who believe their ability to be a physical reaction to the "feel of water" in the immediate proximity, and those whose stimulus and direction seems to come from a psychical impulse. Further new evidence includes the use of the dowsing method in fields other than for locating supplies of water. It is used in locating oil and in gold mining. It is also stated that this method is being experimented with in an effort to employ it in determining the location of obscure ailments of the human body.

To establish dowsing more firmly as a science a section of the book is devoted to "theory." French and German authorities on dowsing are there quoted. There is also a description of the instruments used by dowsers, other than the classical forked twig. These include the rod made of a variety of materials, and the pendulum, and "regulable pendulum" which has been perfected in France.

The author's solid belief in dowsing is evident. He thinks that the dowser is successful because he has "other than normal" powers.

The final chapter on the "Folklore of Dowsing" is a delightfully written historical sketch concerning the magician's wand, and the Divining Rod and popular beliefs adhering to these ancient instruments in many countries.

Plates and "text plans" are used to illustrate the book and there is a three page index.

A FURTHER ANALYSIS OF REASONING IN RATS. *II. The Integration of Four Separate Experiences in Problem Solving. III. The Influence of Cortical Injuries on the Process of "Direction." Comparative Psychology Monographs. Volume 15, Number 1. Serial Number 73.*

By Norman R. F. Maier. Johns Hopkins Press, Baltimore. $1.50. 10 x 6¾; 80 + 5 plates; 1938 (paper).

THE EFFECT OF EARLY INANITION UPON MAZE LEARNING IN THE ALBINO RAT. *Comparative Psychology Monographs. Volume 15, Number 2. Serial No. 74.*

By William C. Biel. Johns Hopkins Press, Baltimore. 75 cents. 10 x 6¾; 33; 1938 (paper).

In the first paper Maier shows, by a series of well organized and carefully controlled experiments, that white rats are capable of integrating several experiences and using them, to some advantage at least, in problem solving. Analysis of the scores shows that the rats made 55.0 per cent completely correct responses when chance expectation would be 25.0 per cent. The second paper deals with the influence of cortical injuries on the process of "direction" in white rats. The data here show that cortical injury probably has not as great an effect on the reaction to a problem as does preoperative training. Both papers present extensive bibliographies, graphs and tables, and the latter is illustrated with 5 plates.

Biel reaches the general conclusion that inanition, whether begun soon after birth, or in a later period of life preceded by normal rearing, causes no loss in maze learning ability as measured by error, trial, or time scores on the Warden U-maze or the Stone multiple-T maze. The paper contains many tables and graphs concerning the scores of the animals, and a bibliography of 46 titles.

THE MENTALLY ILL IN AMERICA. *A History of Their Care and Treatment from Colonial Times.*

By Albert Deutsch. With an Introduction by William A. White. Doubleday, Doran and Co., Inc., Garden City. $3.00. 8½ x 5½; xvii + 530; 1938.

This excellent and detailed history of the ideologies which have determined the care and treatment of the mentally ill in America from colonial times to the present day is a valuable and much needed contribution to the literature of psychiatry. The book begins with the days when the mentally ill were believed possessed of demons and treated by exorcism or hung as witches. It continues, describing how they came to be regarded as sub-human

beings chained in kennels and whipped; how, later they were sold as paupers on the auction block. The early establishment and later growth of state hospitals and state care is well summarized. Chapters are devoted to Benjamin Rush, the first great American psychiatrist; to Dorothea [*not* Dorothy] Dix; and, of particular interest because not so well-known, to thirteen of the hospital superintendents of the mid-nineteenth century whose vigorous thinking and activity resulted in the founding of the organization now known as the American Psychiatric Association. A thorough and directed study of the problems confronting psychiatric practise, therapeutic, administrative, legal, etc., is made; a chapter is devoted to the problem of mental defectives; also, to the growth of the mental hygiene movement; and the early relationship between American and European psychiatry is indicated. The bibliography is excellent and the book is well indexed.

THE MIND OF PRIMITIVE MAN. *Revised Edition.*

By Franz Boas. The Macmillan Co., New York. $2.75. $7\frac{3}{4}$ x $5\frac{3}{8}$; x + 285; 1938.

The white races today tend to view with superciliousness the cultural achievements of other races. But in 2000 or 3000 B.C. the Egyptians had the same attitude towards what *they* regarded as primitive peoples. Some of these primitives then were the lineal ancestors of our own very important selves. In view of historical changes in the cultural status of races, the degraded position of today's primitives does not necessarily seem a permanent one. Since man is considerably over one hundred thousand years old, "What does it mean, then, if one group of mankind reached a certain stage of cultural development at the age of one hundred thousand years and another at the age of one hundred and four thousand years?"

Following these lines of thought the author penetratingly attacks such general assumptions as that "achievement depends solely, or at least primarily, upon innate racialability"; that "race and culture must be intimately associated"; and that "strangeness of type and low intelligence go hand in hand." These Boas regards as reasonings based on ignorant, emotional, and political prejudices. In the final chapter, the race problem in modern society is considered with frank impartiality.

PRIMARY MENTAL ABILITIES.

By L. L. Thurstone. University of Chicago Press, Chicago. $2.00. $9\frac{3}{4}$ x $6\frac{3}{4}$; ix + 121; 1938 (paper).

This book is an application of the theory of factor analysis described in the author's *The Vectors of Mind* in 1935. The problem of factorial analysis, beginning with the record of objective performances of individuals, is to isolate and describe fundamental abilities. In this study 56 psychological tests were given to each one of a group of 240 volunteers. The nature of these tests and the statistical methodology used in analyzing the results are discussed in some detail. This psychometric approach to the elusive data of psychology is too new to have yielded clear-cut results as yet. As an objective approach to the problems of psychology it is to be commended. Actual test scores are tabulated in the appendix, and there is an index.

EXPERIENCE AND PREDICTION. *An Analysis of the Foundations and the Structure of Knowledge.*

By Hans Reichenbach. University of Chicago Press, Chicago. $4.00. $8\frac{1}{2}$ x $5\frac{3}{4}$; x + 410; 1938.

Led by "the conviction that the key to an understanding of scientific method is contained within the probability problem . . .," the author presents a combination of his investigations on probability with the concept of "logistic empiricism." He proposes that the form of this new philosophical movement should be "probabilistic empiricism." The author repudiates the positivistic conception of the external world and considers probability meaning within the framework of the functional theory of meaning. Knowl-

edge he interprets as a system of posits or wagers.

THE CONTRIBUTION OF ALFRED ADLER *To Psychological Medicine. The Study of Organ Inferiorities. The Subject of the Relation of the Sexes. General Medicine. Also; The Philosophic Environment of Adler's Contribution. Child Guidance in Association with the Teacher. Individual Psychology and Adler.*

By Philip Mairet, Sir Walter Langdon-Brown, H. C. Squires, Cuthbert Dukes, O. H. Woodcock, and others. C. W. Daniel Co., London. 2s. 6d. net. 8½ x 5⅝; 76; 1938 (paper).

This pamphlet, published as a tribute to Alfred Adler, contains seven articles by personal associates. The first article is a presentation of the philosophical background of Adler's teachings. The next four deal with Adler's contributions to various aspects of psychology and medicine. The sixth paper concerns Adler's contributions towards the understanding and guidance of problem children. The last paper is more or less an appreciation of Adler as a human being. All of these papers are extremely laudatory and possibly may arouse a certain amount of irritation among those inclined to evaluate the distinguished propositus more dispassionately.

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE EVOLUTION OF PHYSICS. *The Growth of Ideas from Early Concepts to Relativity and Quanta.*

By Albert Einstein and Leopold Infeld. Simon and Schuster, New York. $2.50. 8 x 5½; x + 319 + 3 plates; 1938.

The first great triumph of physics, Newton's analysis of the motions of the planets, depended on the assumption of a force between particles, acting in the line joining them and depending only on their distance from each other. With the development of knowledge of electric and optical phenomena, however, the attempt to interpret them by means of mechanical concepts met with grave difficulties. A moving electric charge acts on a magnet but the force, instead of acting in the direction joining the charge and the magnet, acts in a direction at right angles to it. Furthermore the magnitude of the force, instead of depending only on the distance between the charge and the magnet, depends also on the velocity of the charge. In order to interpret these new phenomena Faraday and Maxwell introduced the concept of an electromagnetic field, the concept of an orderly system of forces extending throughout the space around the charge or the magnet.

The special theory of relativity, which applies only to systems in which Newton's law of inertia is valid, is based on two fundamental assumptions: (1) physical laws are the same in all systems moving uniformly relative to one another: (2) the velocity of light always has the same value. The general theory of relativity applies to all systems, whether inertial or not.

The older physics regarded matter as made up of elementary particles but energy was conceived as continuous. Later results have shown that the latter too is discontinuous in structure.

Is light a wave or a shower of photons? Is a beam of electrons a shower of elementary particles or a wave? These fundamental questions are forced upon physics by experiment. In seeking to answer them we have to abandon the description of atomic events as happenings in space and time, we have to retreat still further from the old mechanical view. Quantum physics formulates laws governing crowds and not individuals. Not properties but probabilities are described, not laws disclosing the future of systems are formulated, but laws governing the changes in time of the probabilities and relating to great congregations of individuals.

Apparently Royce, the advocate of the statistical method as the fundamental description of reality, was a prophet of modern physics.

"SO YOU THINK IT'S NEW."

By Wilfred J. Funk. Drawings by Russell Sherman. Funk and Wagnalls Co., New York and London. $2.00. 8 x 6; x + 198; 1937.

This delightful little volume should be in every man's library no matter what his age or occupation. In these days of new deal, new social experiment, new this and that, it is refreshing to learn that there are still some persons well enough acquainted with the history of the past to realize that the contemporary sometimes suffers from delusions in evaluating the contributions of his age. In a light and thoroughly enjoyable vein the author discusses many topics from the art of make-up to that of graft, and shows the close resemblance between the present and the remote past. The student of biological sciences will find particularly amusing the verbal coincidence in the advice on the care of infants as given by Soranus, the Greek physician of imperial Rome, and by one of the most eminent pediatricians of this country.

THE INTELLIGENT INDIVIDUAL AND SOCIETY.

By P. W. Bridgman. The Macmillan Co., New York. $2.50. 8½ x 5¾; vi + 305; 1938.

The distinguished physicist who writes this book has been thinking rather seriously about the relation between the individual and society. In this exposition of his thoughts on the subject he introduces the reader first of all to the operational methods used in modern physics. Then he proceeds to analyze social behavior more or less according to these methods. He finds as a result, as many would expect, that man's social behavior is not often rational. In view of this, the author proposes as a remedy to the ills of society and a means of happiness that (1) the fact of the irrationality of social conduct should be realized by all; (2) the golden rule in a form modified by him should be universally applied; and (3) force should be used to bring in line those who do not act by this golden rule. Engagingly written, the book is pleasant to read and contains a number of bright if not entirely original ideas. It would seem that in matters regarding social behavior even the intelligent individual is at a loss since the best he can do is to propose cures which, sad to say, have already proved unworkable.

SCIENTIFIC ILLUSTRATION.

By John L. Ridgway. Stanford University Press, Stanford University, California; Oxford University Press, London. $4.00. 10 x 6½; xiv + 173; 1938.

It is a well-known fact that a simple drawing will produce a greater effect than a lengthily written delineation. Unfortunately too many authors interpret this idea literally and become satisfied that they are doing their duty by merely inserting illustrations of any sort, no matter how poor they may be. The purpose of this book is not to teach free-hand drawing or cartography, but to show which of the various methods of illustration are most appropriate and how the best effect may be obtained from them. The author has had much experience and he covers the field thoroughly. The scientific writer who desires to illustrate his article will find all the information he needs and the professional artist will likewise derive benefit from this comprehensive and profusely illustrated manual.

INTERNSHIPS AND RESIDENCIES IN NEW YORK CITY, 1934–1937. *Their Place in Medical Education.*

Report by The New York Committee on the Study of Hospital Internships and Residencies. The Commonwealth Fund, New York; Oxford University Press, London. $2.50. 9 x 6; xxx + 495; 1938.

This book is the result of a comprehensive study made by a joint committee representing the College of Physicians and Surgeons of Columbia University, Cornell University Medical College, Long Island College of Medicine, New York Medical College and Flower Hospital, New York University College of Medicine, and the New York Academy of Medicine, and financed by a grant from the Commonwealth Fund. The study represents a thorough analysis of internships and residencies in 77 hospitals in New York City, and the resulting data are presented

as a basis for determining how best the internship years can be made to supply a high standard of training adequate to the present day practise of medicine. The experience of previous interns is reviewed, the educational value of the internship is discussed, record keeping, health conservation of the house staff, hospital libraries, desirable activities of internship and residency years, and certification in the specialities are considered. The book will be of value and interest not only to medical school and hospital administrators but to medical students with internships still to be decided on, and to interns and residents whom the subject matter most closely touches. There is a bibliography and the book is indexed.

SMOKE REDUCTION. *A Standard Instruction.*

By R. S. Gill. The University Club, Baltimore. 5½ x 4; 14; 1937.

This booklet, concerned with smoking among office gals (especially at inopportune times) suggests a method whereby the situation can be effectively handled. Unfortunately the author does not report concrete results.

THE PRICES OF BIOLOGICAL BOOKS IN 1938

By RAYMOND PEARL AND MAUD DEWITT PEARL

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WHEN the QUARTERLY REVIEW OF BIOLOGY began publication in 1926 the custom was inaugurated of reporting at the end of each volume on the cost of the books that had been reviewed in its columns during the year. The present paper, therefore, is the thirteenth of these reports on the cost of biological books. The prices of foreign books have been converted into dollars on the basis of the exchange at the time the books were received. Table 1 shows the findings for 1938, arranged in the customary manner.

The total number of pages reviewed in 1938 is 149,046, an increase of 8,686 pages, or 6.2 per cent over 1937 and an increase of approximately 81 per cent over 1926, the year in which these tabulations began. In the thirteen years of the QUATERLY REVIEW's history the books reviewed in these columns have aggregated a total of 1,624,664 pages. To American buyers these cost in the aggregate a total of $17,609.43, leading to an average price per page for the total of 1.084 cents. The weighted average cost of 1.024 cents per page for all the books reviewed in 1938 is 6.1 per cent lower than that for all the books reviewed in our columns during the preceding twelve years 1926–37 inclusive, taken as a bulk total. It is even lower than the corresponding average for 1937 of 1.053 cents per page by 2.7 per cent. The 1938 average price per page for all books reviewed is 6.7 per cent lower than the corresponding figure for 1926, which was 1.097 cents. The general picture presented by the 1938 summary is clearly of a continuation of the lowered prices that got under way in the 1937 report. The American biologist buying books in 1938 got off relatively easily, as compared with other years, so far as may be judged by our review sample. From his point of view a further continuation of the trend of these last two years would be a real and undisguised blessing.

In 1938 Germany stayed in her customary position at the head of Table 1, as the source of origin of highest prices for biological books. And, in general, all the sources of origin stood this year in about their usual order. It does not appear that the announced policy of the German publishers relative to book prices that has been discussed in these columns in recent years has produced much of a realistic effect in lowering average prices. Quite on the contrary Germany's average price per page in 1938, as judged by our sample, was actually 19 per cent higher than in 1937. There may be some deep and subtle economic principle of a beneficent character involved in the price policy of the German publishing trade, but if so it is hidden from the ordinary mortal's understanding. There would seem little doubt that the relatively high prices of German biological books, and the generally upward trend of those prices during

TABLE 1

Prices of biological books, 1938

ORIGIN	TOTAL PAGES	TOTAL COST	PRICE PER PAGE
			cents
Germany	8,025	$185.90	2.32
Other countries	2,550	55.49	2.18
British-American	12,351	142.95	1.16
Great Britain	13,685	142.44	1.04
United States	95,022	909.86	0.96
France	10,630	76.84	0.72
British Government	383	1.74	0.45
U. S. Government	6,400	10.60	0.17
Totals and weighted average, 1938	149,046	1,525.82	1.024
Totals and weighted average, 1926–1937 incl	1,475,618	16,083.61	1.090

The average prices per page of our samples of biological books from every origin except Great Britain, British-American, and France were *higher* this year than in 1937, by amounts ranging from about 3 per cent for books commercially produced in the United States to 153 per cent for the "Other countries" publications. In spite of the fact that only three sources of origin showed lower prices in 1938 than in 1937 when considered separately, the importance of these sources together with other changes in the volume weighting led to the general average for all books together being lower this year than last, as has already been seen from Table 1. The 1938 average price per page for books commercially published in the United States was 15.8 per cent lower than that shown by our 1929 sample. The rise in the per page price of biological books published in France, which has been commented on in these notes in recent years, did not continue in 1938. Instead the 1938 average price was 15.3 per cent lower than the 1937, and absolutely fell back to the level characteristic of the years around 1931–33. Our sample of biological books from British commercial publishers showed a 19.4 per cent drop in price from the 1937

TABLE 2

Comparison of the prices of biological books for the decade from 1929 to 1938

ORIGIN	AVERAGE PRICE PER PAGE										CHANGE + OR − FROM 1937 TO 1938		CHANGE + OR − FROM 1929 TO 1938	
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	Absolute	Relative	Absolute	Relative
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*per cent*	*cents*	*per cent*
British-American	1.90	1.91	2.27	1.48	1.29	1.45	1.53	1.81	1.44	1.16	−0.28	−19.4	−0.74	−38.9
Other countries	1.68	0.97	1.53	1.02	0.85	0.86	1.20	2.26	0.86	2.18	+1.32	+153.5	+0.50	+29.8
Great Britain	1.29	1.13	1.19	0.89	0.66	0.96	0.84	0.94	1.27	1.04	−0.23	−18.1	−0.25	−19.4
United States	1.14	1.09	1.05	1.00	1.02	0.93	0.90	1.03	0.93	0.96	+0.03	+3.2	−0.18	−15.8
Germany	1.65	1.82	1.75	1.60	1.43	1.89	2.04	1.84	1.95	2.32	+0.37	+19.0	+0.67	+40.6
British Government	0.39	1.19	1.03	1.45	1.39	0.89	0.50	1.62	0.34	0.45	+0.11	+32.4	+0.06	+15.4
France	0.47	0.47	0.69	0.60	0.74	1.00	0.86	1.05	0.85	0.72	−0.13	−15.3	+0.25	+53.2
U. S. Government	0.23	0.30	0.28	0.36	0.17	0.18	0.11	0.21	0.16	0.17	+0.01	+6.3	−0.06	−26.1

the last thirteen years, has definitely and considerably curtailed and restricted the sale of such books in the United States. Quite apart from any question of correlatively diminished intellectual influence, this would seem a poor way to make money.

Following the custom inaugurated two years ago Table 2 shows the price trends of books published in various countries during the decade from 1929 to 1938 and the absolute and relative changes in price from 1937 to 1938 and from 1929 to 1938.

sample. German books, as judged by our samples, increased in price in 1938 to American biologists, by 19.0 per cent over 1937, and by 40.6 per cent in the last decade.

Table 3 sums up the whole thirteen years experience of the QUARTERLY REVIEW.

TABLE 3

Average biological book prices over the thirteen year period, 1926–1938 inclusive

ORIGIN	TOTAL PAGES	AVERAGE PRICE PER PAGE
		cents
Germany	172,968	1.621
British-American	114,766	1.558
Other countries	52,311	1.368
Great Britain	133,546	1.027
United States	958,530	1.023
British Government	9,219	0.911
France	132,852	0.697
U. S. Government	50,472	0.226
Total and weighted average.	1,624,664	1.084

It is evident, from what has now grown to be a substantial sample, that during the past thirteen years biological books from all over the world taken together have averaged to cost the American biologist very close to a cent a page, taking good, bad, and indifferent together. Furthermore it is plain that the sources of origin of these books fall into three fairly sharply defined groups relative to unit prices to the American buyer. In the first or relatively high priced group fall books in the British-American, Germany, and "Other countries" categories of origin. The primary reason why the British-American books fall in this category is because they carry an import duty charge, paid on the sheets manufactured in England but issued here by an American branch house. The next or medium priced group includes the United States, British Government, and Great Britain (commercial publishers). None of the books in this category carry import duty charges in the prices here tabulated, because in the case of the British books the English prices are used. Actually an American buying these books would have to pay duty. This would then, in fact, throw them into the same group as the British-American publications. Finally the third or relatively low price group includes books published in France and by the U. S. Government.

The reader should bear in mind that these reports are based on small samples of books in general and, for some countries, on small samples of the biological books published. He should therefore be cautious in applying conclusions drawn from this material to the general domain of book prices.

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